Guidelines for statistical monitoring

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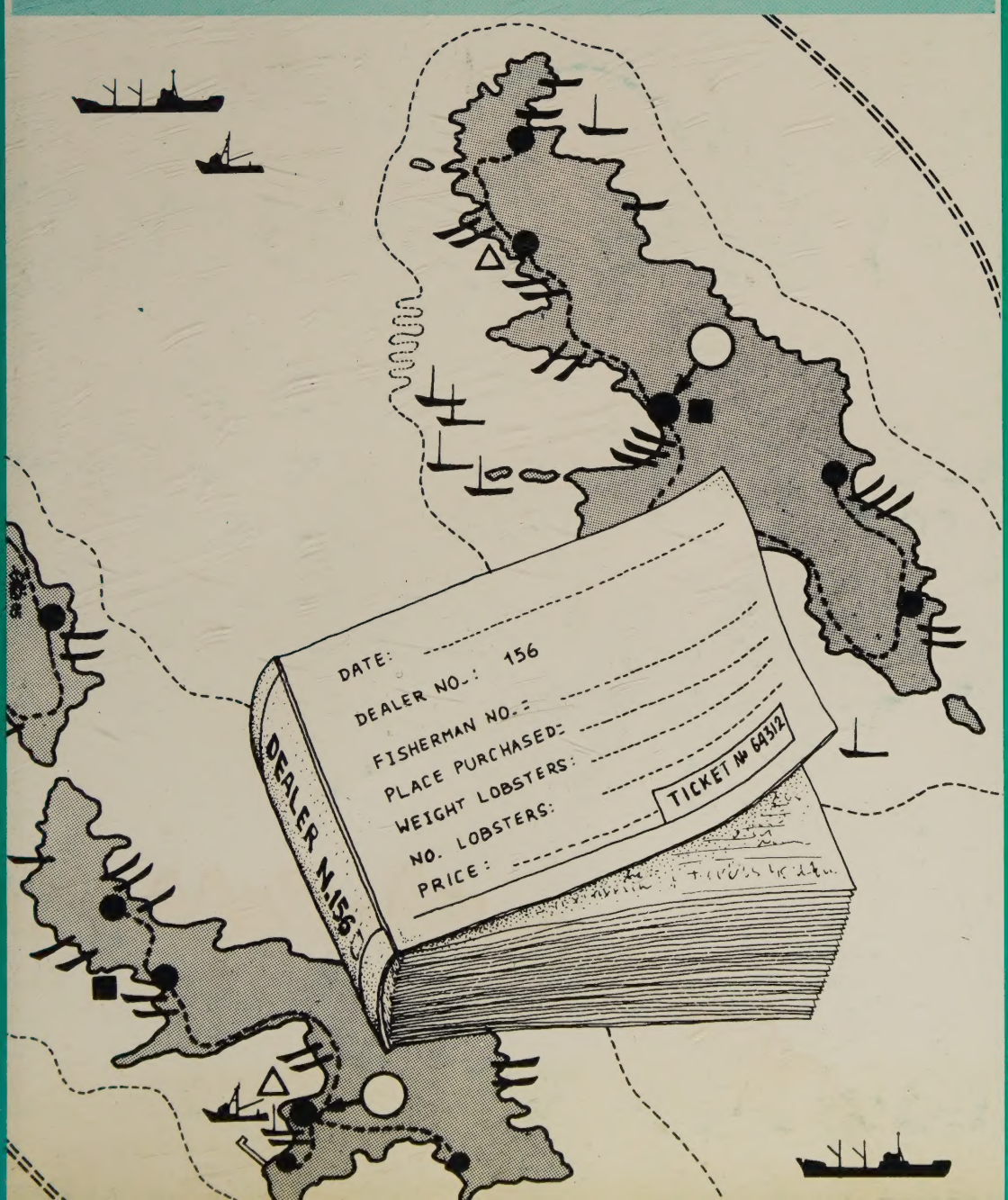

FOOD
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Practical guidelines for statistical monitoring of fisheries in manpower limited situations

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FOOD
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AGRICULTURE
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UNITED NATIONS
Rome, 1985

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M-40
ISBN 92-5-102256-9

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PREPARATION OF THIS DOCUMENT

While the present paper was written with the special concerns of small island states in mind, it is clear that a much wider application can be envisaged, namely to other countries where trained manpower is in short supply. The growing interest shown by some groups of island states in coordinating their fisheries legislation, information gathering systems and even in management of fishery resources with their neighbours, makes it possible to consider whether economies of scale are not feasible and can be achieved at a national or international level in fields related to fisheries. Some of the difficulties of implementing conventional data gathering systems by sample survey, and in designing and maintaining proper up-to-date storage and retrieval systems for small island states on a rational basis are reviewed in this document. Statistical sampling and data storage systems are logical areas for coordination for countries sharing a common geographical area and resource, and some general information is provided that may be useful to national administrations in planning their own systems, or discussing coordination in data gathering with others.

Distribution:

Fisheries Department
Regional Fishery Officers
Selector SM

For bibliographic purposes this document should be cited as follows:

Caddy, J.F. and G.P. Bazigos, 1985. Practical guidelines for statistical monitoring of fisheries in manpower limited situations. FAO Fish.Tech.Pap., (257): 86 p.

ABSTRACT

The main categories and uses of fisheries-related information by fisheries administrations for stock assessment, resource management, investment, planning and economics analysis, and for social and nutritional studies are briefly discussed in this document, and the appropriate scale of these activities is illustrated using as example the constraints faced by fisheries administrators of small island states in funding and manpower in the fisheries sector. Special emphasis is placed on the types of data that can be collected by fisheries officers, and which already exist, and are available to them from other sources.

Mapping current information on the resources, the fishermen, and their employment status, the seasonality of the fishing operations, the type and number of boats and gear used, location of wharfs, landing sites, markets, shore plant and boat repair and building facilities, not to mention catches and other biological information and the main routes for transshipment and import/export of fish products, is a necessary first step towards considering the type and scale of statistical monitoring, and in designing a filing and monitoring system for the fishery.

In planning such a system of work, the administrator will have to ensure that the fisheries officer coordinates with other organizations collecting relevant data, in order to make optimal use of existing manpower. Collection methods based on the interview approach and sampling surveys may have to be used with care, and emphasis given instead to the commissioning of data gathering by key individuals (data sources) outside the government and strategically located within the fishery system, and to the use of simple logbooks or sales slips (which may be legislated as a requirement for licensing of fishermen or dealers). The field activities of officers should where possible, follow a present sampling design in order to maximize utility of these observations. Their data gathering activities should also be aimed at ensuring a high level of reliability of the data received from other sources. Quality control methods should be introduced aiming to ensure high quality of the statistics produced and in debiasing wrong estimates.

Some general guidelines are suggested for design and maintenance of data storage and retrieval systems, and the importance of feedback of useful data to the industry while protecting individual sources, is emphasized.

A set of draft forms is provided for data-gathering in a variety of disciplines, that with priorization and modification to suit local needs, may provide a useful basis for an integrated fisheries data base of value to fishery planners.

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1. INTRODUCTION

1.1 Manpower Shortages in Data Collection

The manpower and budget for covering all aspects of the fisheries sector available to the relevant government departments of developing countries is usually very limited, reflecting in part the governmental priorities in fisheries relative to other sectors of the economy, and in part, the total size of the budget itself. Because of these limitations, economics of scale are impossible, and often one, or only a few officers are provided to cover all of the many functions coming under the heading of fisheries; e.g., registration of fishermen, fishermen's affairs, fishery regulations and their surveillance, advice on resources and their assessment, marketing, as well as on fisheries development issues. Collection of basic statistics will often be perceived to be low in the order of priorities, and may be neglected, particularly since the collection of data is seen to be mainly useful for long-term planning. In the absence of staff and facilities to properly record, store and analyse the data, collecting statistics may seem at first sight, to be less important than the day-to-day priorities with which the officer is faced. An approach that takes account of these limitations is illustrated with particular reference to small island states, but has obvious applications elsewhere.

While suggesting that such an approach is mistaken, it is recognized that because of the small-scale of the population under investigation and the limited staff, many statistical survey techniques applicable to large countries are inapplicable to many small states. Some approaches to cost-effective and statistically efficient survey techniques are suggested here, while recognizing that the priorities suggested in this document will still in many cases, require administrators to reprioritize activities from their own local perception of available objectives and resources. Nonetheless, the systematic application of effort towards developing sources of information outside the Fisheries Department, especially with cooperation of fishermen and industry, will ensure that the officers do not depend exclusively on first-hand collection of information, but spend more time on checking the quality of the produced statistics, and the processing, presentation and interpretation of the results for government policy-making.

Although very precise statistical estimates of magnitude expressed by their sampling variances will not usually be obtainable, it seems likely that important trends, problem areas and opportunities will still be identified by a limited, but integrated statistical service, and can be the basis of informal action by administration.

Collection of statistics is not an end in itself, but is essential for well-informed policy decisions taken by government or the fishing industry. This information may be used by policy-makers, or as necessary input to various specialized analyses. Just what these analyses should be is beyond the scope of this document, but an attempt has been made to suggest what type of information is required, with what frequency it is needed in each case, and how it should be collected. The main questions underlying these applications are considered to fall under the following headings:

1.2 What is the Present State of the Resources?

Will increased fishing pressure produce more food, and if so, at what cost? Alternatively (as is the case for many island shelves) will the yield only decline with further effort? Determining which of these alternatives applies is crucial to deciding what proportion of investment should be in the catching sector, are in other sectors, including management. We need here current data on catch rates by key species, on species composition, and current estimates of total landings by area captured, in order to make an assessment of the state of resources. Current estimates are also needed on the number of boats actively fishing (both foreign and domestic), the number of days fishing per trip by the fleet, and the number of trips per month, as well as the gear vessel type used.

Transshipments and imports of fish need to be distinguished from those locally caught to avoid double counting. Some data are needed on size and distribution for properly identified key species and their catch rates.

1.3 What is the Economic Performance of the Primary Fishery Sector?

Some of the questions that will require special information to answer in this sector are: How is the economic performance assisted or otherwise affected by various actions of

the government and private sector? What is the ratio of return to input of private and government investment in the fisheries sector? For these purposes, information is needed on fish prices (at various levels of transaction) for the various categories of fish, and how these respond to changes in supply, and on the prices received at landing points and on costs of catching, processing, and distribution of locally caught fish, both in the country and for export. In many cases it will prove advantageous to consider differnt approaches to information collecting for artisanal versus industrial fisheries.

1.4 What are the Fishermen's Earnings?

What are the impacts of government policies on the fishermen, e.g., in enabling them to finance purchase and replacement of equipment, boats and fishing gear? Are these materials in good supply at reasonable prices? Are suitable sources of credit available? Data on these points need to be collected and maintained in the Fisheries Department's records.

Cost-earnings data are required for assessing the economic viability of the operating fishing units and the provision of information on gross revenues, operating costs and earnings of the fishing units.

1.5 What do Fisheries Contribute to the National Food Supply?

Are all sectors of the population receiving supplies of fresh, processed or frozen fish and how much is being consumed of local versus imported fish? Building of an information base of this type may not be solely the responsibility of the Department of Fisheries and Agriculture, and will often need to be tackled in cooperation with other government sectors.

1.6 What are the Net Earnings of Foreign Exchange from Fisheries?

Here we must include expenditures of foreign exchange for importation of boats, engines, fuel, fishing gear, etc., as well as of fish imports (canned, dried, fresh or salted), and foreign exchange earnings from fish exports in order to arrive at a proper balance for the sector. Unrecorded sales (over the side) or national landings in adjacent territories need to be included here, even if such estimates are very provisional.

All of the above questions are interdependent, and the answers to some of the later ones will depend on knowing the state of the resources. For example, the effective economic returns to the national economy as a whole from investment in new vessels depends not only on costs and earnings of these vessels, but also the degree to which their catches (by competing for limited resources) will cause changes in catch rates, and hence changes in income plus economic performance for existing vessels. Reference is made to Troadec (1983), MacKenzie (1983), Christy (1982) and Panayotou (1982) for more background on considerations related to the economics of fisheries.

2. OVERALL POLICY AND STRATEGY FOR STATISTICS COLLECTION

Any industry requires some government expenditure for its administration and to carry out the relevant research and information-gathering functions. There appears to be no firm guidelines as to the prior level of expenditures that should be devoted to this governmental activity, which depends on a wide variety of considerations, not all related to the question of fisheries production. Thus, the desire to maintain employment or to keep people in coastal communities, or to avoid political conflicts internally, are among some of the factors that can cause governments to make expenditures on the fisheries sector *per se*. Leaving aside these quite valid considerations (which derive their justification from outside the fisheries sector regarded as a productive activity), the appropriate policy to pursue if the fisheries sector is to be a net contributor to the economy, is for government expenditures in the sector not to exceed some percentage of either the present net revenue from the sector, or of the potential net revenue if all underexploited resources were to be harvested efficiently. Thus, if it is appropriate for expenditures not to exceed say, 5-20% of the annual value for a fully developed fishery (and of course a higher percentage than this in the development phase), then the expenditure on one function, data collection, should be a fraction of this figure. No attempt will be made here to generalize further on the appropriate level of expenditure on statistics collection, but for small island states, especially for island archipelagos, a relatively high proportion of the national resource income will need to be expended, given the scattered nature of fishing communities and the lack of large ports and fisheries enterprises that permit cost-effective data collection. This again argues for a cost-effective approach to statistical collection.

In the case of small shelf fisheries which are vulnerable to overfishing (e.g., conch and lobster fisheries in the Caribbean) the stocks may disappear if not properly managed. The costs of rehabilitating these resources are likely to greatly exceed revenues for a number of years to come, and in these cases data collection should be made an integral part of any management plan decided upon.

In addition to the above considerations, one compelling reason for a large government involvement in fisheries, particularly for small island states, is that fisheries usually operate on a common property resource, a resource owned by the country as a whole. Since extension of economic jurisdiction to 200 mi by most island states in the late 1970s, the territory proprietary to the nation is often increased twofold or more, and the fisheries of these areas are often their most valuable actual or potential assets. This should lead the government to become deeply involved in the planning and management of the fishery, with a requirement for reliable data at this early stage of ownership being regarded as a national priority (see Burke, 1982).

In designing and operating a statistical system in severely limited manpower/resources situations, it must be recognized that the results will only be as accurate as the effort expended by the government fishery service.

The first thing to do is to identify on the one hand, the types of data needed, and the priorities and procedures for the collection of the spectrum of characteristics required, and on the other hand, the budget and manpower available for the implementation of the system of work for data collection.

2.1 Frame Surveys

A complete census or count of the main units (ports, plant, boats, fishermen, markets and transportation routes) is essential for the proper statistical collection of information on the primary fishery sector. This includes:

1. Existing ports and landing places and their pattern of distribution.

2. Number of fishing units and information on their components, such as fishermen, fishing boats, fishing gear, and the clustering pattern of the fishing units (widespread, or clustered into fishing ports and landing places).

3. Fishing and landing habits of the fishing units and the diurnal and seasonal pattern of activity in the fishery.

4. Supply centres for capital goods and essential materials (e.g., gasoline, netting, etc.).

5. Fish distribution routes, processing and marketing habits and related costs, etc.

For the collection of the information required[1/] from the traditional and artisanal fisheries, the best approach to Frame Surveys is by water or road, supplemented if possible by low-cost remote sensing techniques (Aerial Frame Surveys). For a complete inventory of information from industrial fisheries, either the interview or the reporting approach can be used.

The pattern of rotation of the frame surveys i.e., how often the surveys should be conducted, is a function on temporal changes in the size, distribution and operational aspects of the target fishing population. For traditional and artisanal fisheries, it may be necessary to carry out a frame survey every one or two years.

Part-time resources are needed for carrying out Frame Surveys and Aerial Frame Surveys. Once completed however, it is possible to make continual observation to update the original frame in the course of routine activities of fishery officers.

1/ See Bazigos (1974) for details of the design and operational aspects of Frame Surveys and Aerial Frame Surveys

2.2 Current Catch Assessment (CAS) and Related Surveys

CASs are surveys over successive occasions aiming at collecting current information on total catch and fishing effort exerted by the operating fisheries. For the traditional and artisanal fisheries, sampling in space and time is used for data collection. For industrial fisheries the census method is usually used.

The operational steps in the sample design of a CAS involves the selection of the sample of ports and landing places (sampling in space) and the selection of the sample days (sample period) within the established reference period (= month, quarter, etc.) for obtaining the required information from a sample of boat landings within the sample ports and landing places.

For field operations during a CAS, recorders should be trained and assigned to the survey, possibly on a temporary basis. Other items of cost include transport, fuel, mapping materials, etc. Personnel in the Ministry of Agriculture and Fisheries must have this function spelled out in their work plans and budget on a non-discretionary basis, especially if employed temporarily.

Although the thesis of this publication is that CASs are not absolutely indispensable in following trends, they should be strongly recommended at intervals of five years or so to assess absolute magnitude of the catch and other important characteristics of the fishery.

2.3 Existing Resources Allocated for Related Functions

Records of fish imports, exports and transshipments may already be collected by custom agents, exporters and food retailers, harbour masters or other government departments. Information on names and numbers of fishermen by community may also be collected by social workers, and/or by inland revenue (if approached with discretion). Other government or municipal departments concerned with regional development that may collect various relevant statistics, such as on fish consumption may also help here. Data on sports fishing (e.g., tournament records) may be available, and provide some index of changes in abundance and size composition of important species.

Harbours masters may also provide information on the number of boats registered for fishing, or leaving port daily, or on numbers of boats transshipping fish in the port, and can help in maintaining an up-to-date boat registry.

In all these cases, explanation of the six rationales spelled out earlier on in this document, can often result in data being collected, or even special information being recorded with no extra manpower, and little or no extra cost.

3. RESOURCE MAPPING

3.1 Spatial Components of Statistics Gathering

The importance of an appreciation of the geographical distribution of economically important activities and their interconnections is essential for activities like statistics gathering and resource management, since distance of fishing areas from the fishing communities exploiting them is an important consideration in relation to costs of fishing, but also in the setting up of sampling systems. Proper location of observers in relation to geographically strategic points is a major factor in reducing the costs in travelling between sampling sites. In a very real sense, a map portraying information from all sectors related to fisheries (a thematic map) can be one of the easiest ways of seeing at a glance, the various factors related to the sector as a whole (see Figure 1).

3.2 Thematic Mapping

In talking about the concept of a thematic map, Butler (MS) notes that "...in contrast to the marine navigational tool or the terrestrial reference map, the thematic or geographic map is designed to communicate geographical concepts: distribution of densities, relative magnitudes, gradients, spatial relationships, movements and numerous other distributional relationships". The information is portrayed visually with the aid of colour and symbology: the presentation of qualitative and quantitative marine resource data in this manner permits the following:

- an indication of existing and potential marine activities, hence assisting in the resolution of conflicts between multiple users of the coastal zone, e.g., aquaculture and tourism;

- an assessment of the current status of national and regional fisheries;

- the identification of information gaps and research needs;

- an indication of the level of reliability of the data; an important point when considering diverse information sources.

We may add that in relation to fisheries statistics collection, a large thematic fisheries map pinned to the wall in the fisheries department office, has the following uses:

- it facilitates discussion of work schedules by ensuring that everyone shares a common perception of the resource and the fishing sector,

- it helps confirm travel plans when visiting landing sites, etc.,

- it is essential to discussion of siting of development projects,

- it provides a logical framework for subdividing the area into statistical districts (= strata),

- it is an important and rapid cross-reference for the statistics and filing system.

Many other uses of such a map or maps will occur in specific situations, and it should be updated as new information is gathered (e.g., Table 1). In particular, the location of new landing points, processing plants and routes for transportation of fish to markets can be indicated, as well as points for import or export of fish or fish products (e.g., Figure 1).

3.3 Display of Data

A separate category of map is that used to display the results of a statistical survey. Such a type of map (e.g., Figure 2) may be especially valuable in planning and in illustrating problems to laymen and politicians.

4. STATISTICAL SAMPLING PROCEDURES

The conventional approach to statistical sampling of a production system consists of three main components:

1. Definition of the sampling framework, in which the size and main features of the system to be sampled are exhaustively listed, described and mapped.

2. The frame is used to plan sampling activities of a number of officers following a rigorous plan of activities, such that each one of the main productive components has a known probability of being sampled, so that the results of the survey allow the total production to be estimated over the period of the survey with a known degree of error.

3. One or more quality checks are usually built into the survey, detect and allow compensation for biases in sampling.

Such a three stage sampling approach in fisheries is often carried out over a relatively short period of time by a fairly larger number of sampling officers (see Bazigos for details), and may be updated at regular intervals. This procedure is the one to be recommended if temporary manpower (e.g., student assistants) are available, but imposes problems for many small island states where such manpower is not always available. However, it is useful to consider a little further the components described above, in the fisheries context, before looking for alternative approaches.

Table 1

Provisional list of main points of landing, transshipment, processing and freezing for small- and large-scale commercial fisheries, and sports fishing centres for Andros and Abaco Islands, Bahamas (from Caddy, 1981)

Geographical subdivision	Community	Landing point	Large-scale fishery	Small-scale fishery	Sports fishing centre	Processing plant or freezer	Transshipment point or P of E[a/]
Andros Island	Red Bays	o		x	x		
	Lowe Sound	●		x			
	Morgan's Bluff						
	Nicholls Town					2	P of E
	Conch Sound	o		x			
	Mastic Pt	o		x			
	Stafford Creek	o		x			
	Blanket Sound						
	Staniard Creek						
	Coakley Town						P of E
	Bowen Sound						
	Man of War Sound						
	Cargill Creek	o		x			
	Behring Pt	o		x			
Andros Island	Mangrove Cay	●		x			P of E
	Lisbon Creek	o		x			
	Driggs Hill					1	
	The Bluff					1	
	Kemps Bay	o		x		1	
	Deep Creek	●					
	Mars Bay	o		x			
Abaco Island	Walker Cay						P of E
	Grand Cay	●		x		1	
	Carters Cay	●		x			
	Fox Town			x			
	Coopers Town			x		1	
	Green Turtle Cay	●	x			1	P of E
	Treasure Cay					1	
	Murphy Town						Transshipt
	Dundas Town					3	
	Marsh Harbour					2	P of E
	Snake Cay	o	x	x			
	Cherokee Sound		x	x			
	Sandy Pt	●	x	x			P of E
	Hope Town						

a/ Port of entry

Figure 1 Example of a thematic map showing elements useful in constructing a statistical frame. (Modified from Caddy, 1982). (N.B. Although based on the fisheries infrastructure of Bahamas, this is for demonstration purposes only, and is not intended to represent an up-to-date representation of the current situation)

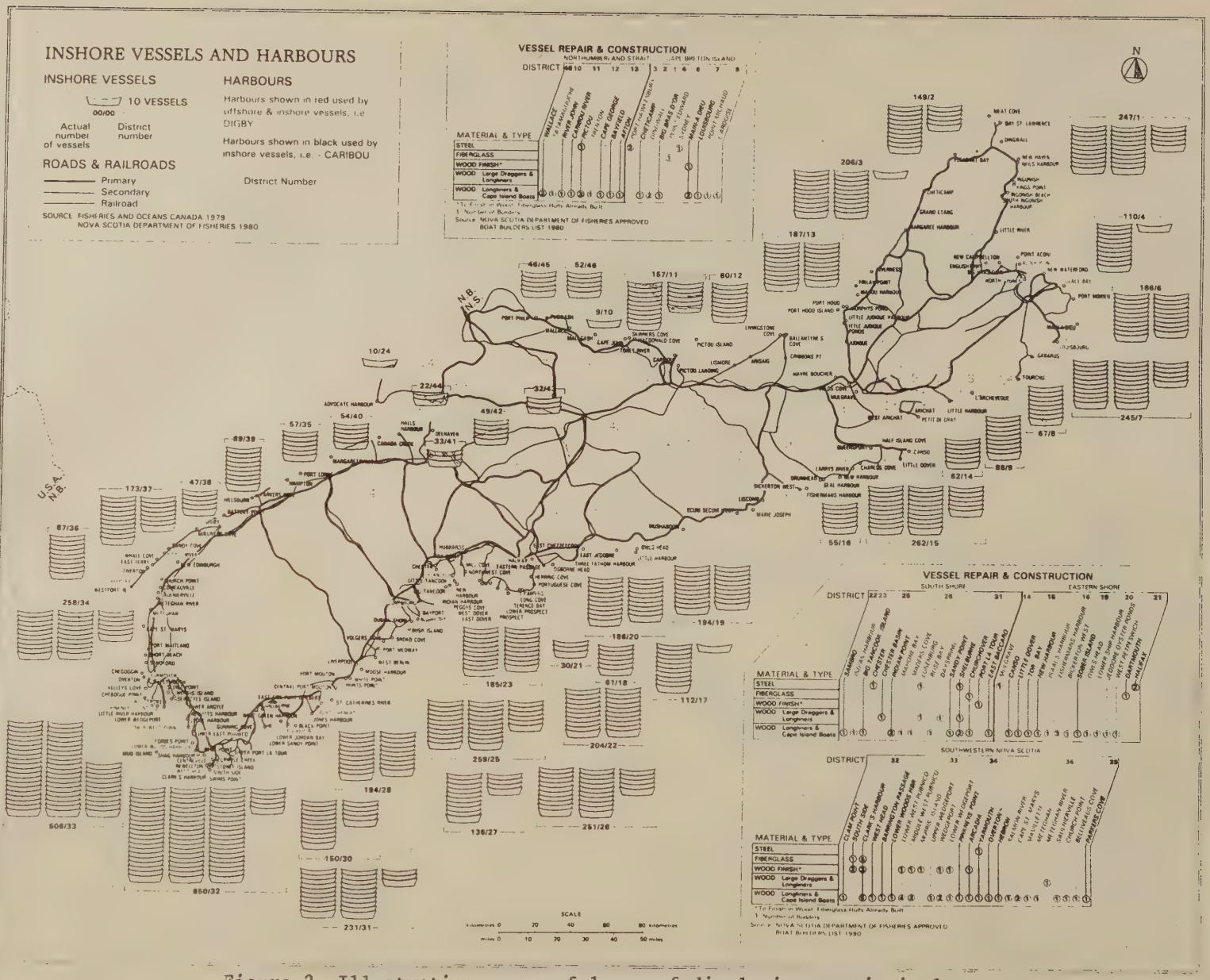

Figure 2 Illustrating one useful way of displaying statistical information for policy makers and planners. (From: Nova Scotia Fisheries Atlas: Nova Scotia Dept. of Fisheries)

4.1 The Sampling Frame

The design of fisheries statistical surveys for collection of the required items of information demands the existence or construction of some form of framework for data collection. Such a framework can be in the form of a map or chart, or an annotated table of key features of the fishery, and is referred to as the "sampling frame". Such a frame is the first requirement for any proper sampling design, and dictates the field operations that follow. For simplicity, the "frame" may be considered as a map showing principal points of landing for each of the main fishing grounds. This kind of map is sometimes referred to as an "area frame", and should include principal routes for transportation of fish between landing sites and internal markets, and to markets outside the country (transshipment points), as well as routes for shipment into the country of fish caught outside the national waters, but landed here. An example of such a map is given in Figure 1.

This map should be updated as new information becomes available, and files should be kept for each of these landing points, listed and categorized as in Table 1. Separate, but cross-reference files should be kept also on the principal fish species landed, and on the main fishing grounds.

The chart and filing system described earlier can be cross-reference, and used as a basis for the construction of the sampling frame required for fisheries statistical surveys based on the sample method.

In most cases, Frame Surveys (FSs) based on the census method are designed and executed for the collection of information on the complete spectrum of inventory characteristics required. The results of the FSs are used, among other things, for the establishment of a proper sampling frame.

4.2 Catch Assessment Surveys (CAS)

For the collection of current items information of the input and output characteristics of the operating fisheries (fishing effort, fish catch) CAS's are designed and executed to allow data collection and sampling in both space and time.

The sampling frame established is used for the selection of the sample sites in the CAS. Specifically, for the selection of the sample of landing points (= primary sampling units, PSU's) the method of stratified sampling is employed i.e., landing points are grouped into categories (= strata) according to their importance. An independent sample of landing points is then selected within the established strata. PSU's could then be selected either with equal or unequal probability (see Bazigos (1974) for details).

Sampling in time is employed for the collection of the items of information required within the sample PSU's. Specifically, a number of sample days is allocated to each sample PSU within the established reference periods (i.e., by month, quarter, etc.). Items of information on the survey characteristics are then obtained from a sample of boat-landings within the sample PSU's on the sample days selected.

4.3 Quality Check Surveys

It is important that some time be set aside, particularly by the supervisor, to check on the errors and biases due to either incomplete or inaccurate recording by the statistics gatherers, to investigate conversion factors, and to check on changes or omissions from the sample design uncovered in the cause of the CAS, and to make the appropriate correction, so that these factors can be allowed for in the later stage of summarizing and analysing the data.

5. PERIODIC SAMPLING SURVEYS OR CONTINUOUS MONITORING?

In practice, a number of approaches to data collection of fisheries statistics are used by government departments of fisheries:

(a) Occasional items of data are collected and filed as and when they become available,

(b) A system of continuous monitoring is followed to quantify aspects of a number of characteristic units in order to determine changes with time, which are presumed to represent the whole.

(c) Periodic sampling surveys (monthly, quarterly, annual, biennial or at even longer intervals) are carried out involving a significant work force and carried out for one or several short periods of time.

(d) An attempt is made to collect information from all units on a continuous basis.

These approaches all have their various drawbacks. For instance:

Approach (a) rarely allows broad conclusions on the whole sector to be made with confidence.

Approach (b) can often provide a useful indication of trends in the sector, but no reliable estimates of overall magnitude.

Approach (c) is the ideal one, but relies on availability of significant numbers of technical officers.

Approach (d) is one adopted by many fisheries departments, but is not only more expensive (even than c above), but will almost certainly result in underestimates of main quantities. One variant on the approach that may possibly be useful is however briefly described in Appendix 1.

A further desirable alternative which is rarely implemented may be suggested here, that has relevance in trained manpower shortage conditions.

(e) This is a combination of (b) and (c), whereby the schedule of visits of a few officers throughout the year, are related to the sampling frame in a statistically sound manner, so as to permit statistically sound conclusions to be made.

5.1 Periodic Extensive Sampling Surveys

Here a significant work force spends extensive efforts over a relatively short period of time in getting a "snapshot" but accurate picture of the state of the fishery at regular or irregular intervals (for theory see Bazigos, 1974; Sahney, 1983).

As indicated earlier, three main components are involved here, namely:

(1) A Frame Survey - is used to make a complete list of the characteristics of the fishery as a basis for designing a statistical sampling survey programme. The principal ports, landing places,fleet size and type, and details of the operations of the fleet are documented. Transportation routes of fish and wholesale/retail transfers, transshipments, import and export routes are identified, and fishermen's communities and the main means of subsistence of fishermen and their families are described on the socio-economic side. (This component is required for all approaches to statistics gathering that hope to draw conclusions about the whole system being investigated).

(2) The fisheries catch assessment survey - is ideally carried out by a number of trained observers (statistical recorders) sampling in space and time. Statistical recorders visit a randomly selected proportion of the landing sites, markets or ports identified in the frame, and sample a present number of fishing units at pre-assigned times and days. The survey is run on successive occasions (e.g., monthly, quarterly) and generates estimates of the survey characteristics within the established reference periods.

(3) The quality check survey - is used to establish the accuracy of (2) and to de-bias the calculated estimates, if required.

It should be stressed that this type of rigorously designed survey over time is necessary if one wishes to have an estimate of the landings with measurable precision. It does, however, pose some problems for countries with a small staff in that finding personnel qualified to design and implement the survey is often rather difficult. Technically

qualified personnel might also be required in the design of the surveys. Two other less rigorous approaches can however be used for data collection. A standard approach to monitoring landings, fleet size, catch composition, costs and earnings, etc., from a known portion of the whole fishery is one of these. The other, and more satisfactory one, from the point of view of statistical validity is to modify the classic sampling approach to allow for two or three officers to carry out in time, what would be accomplished by a larger team over a short period. Such an approach is described in more detail in Appendix 1.

5.2 Monitoring Fisheries Data

There are a number of ways of ensuring that some data are continuously being collected for the more important key variables without the statistics officers having to collect them all in person. For these types of data-monitoring exercices however, the statistical officer needs to allocate some of his time for periodically checking the validity of the data for the sites being monitored, and will need to spend time in checking in person to see how valid the monitored data are for describing trends in areas or sites where these type of data are not available.

Listed below are a variety of sources of information where fisheries data are often collected and kept:

(a) Customs officers and harbour masters often keep records on import-export transshipments, and dates/times of departure and return of fishing boats to port.

(b) Departments of manpower or rural development, often keep records on employment of e.g., registered fishermen.

(c) Departments of Health and Welfare may keep records of household surveys that may include fish consumption.

(d) Fisheries Departments may keep records on vessel loans and on the number of registered fishermen.

Regular informal meetings of government officials involved directly or peripherally in fisheries (or even an inter-departmental committee to discuss fishermen's welfare) can be useful in helping to coordinate government efforts in the fisheries sector, save valuable manpower, and avoid duplication.

(e) Key points in the private sector, such as fish dealers, shipping agents, airlines (where high quality fish or shellfish may be leaving the country) can often be persuaded to record information. Here it is important that the confidentiality of such information be respected; if statistics are released (as they should be) the individual records should be combined with others to protect sources.

(f) Fishermen, auctioneers or buyers will sometimes keep records of the quantities, kinds, size categories and prices of fish being sold each day, if a small payment is made to an individual involved in this process, and if on checking by the fishery officer the result is found to be reliable.

5.3 Legislating for Data Collection

Legislating to require buyers to record their purchases on some kind of record sheet is one frequent approach used in many countries to encourage continuous monitoring of statistics. The requirement for receiving proper data is a condition for issuing a buyer's or fish dealer's licence (other conditions being maintenance of good quality fish, etc.). A description of one such scheme that might also include industrial fishermen is given in Appendix 3. For practical reasons, it would be inappropriate to require small-scale fishermen to keep such records; an interview approach is the one to use for data collection in the artisanal sector.

Clearly, this monitoring function is one which, if applied and controlled with care, can yield a great deal of information with relatively low manpower input. The result, however, is not necessarily going to provide correct figures for total landings, without a good deal of extra work by the statistical officer, to identify gaps in the statistics,

e.g., to estimate that proportion of fish not going through markets or wholesalers and to cover these off by direct observation, or quality check surveys.

5.4 Continuous Random Sampling by One or Several Statistical Officers

In theory, it is possible to carry out a sampling survey as above, with a limited team of one or two full-time statistical officers visiting a sequence of ports on a year-round regular basis to sample a randomized number of vessels at each port. This, in fact, is probably a reasonable way of scheduling the full-time activities of a statistical officer. It is understood that the statistical officer has in his office a map of the main sampling points (a frame survey is obviously still necessary, and should be updated continuously), and that his diary and work schedule has been organized in advance of the season, assigning times and dates to visit each port/landing, site/market on a stratified random basis. (Larger ports with more landings and a higher diversity of vessels or types of catch are grouped into priority (weighted) strata, and visited more frequently than small ports, which are also visited randomly.) The officer's work schedule is to be followed with very little discretion in substitution of one port or date for another. A quality check by the supervisor, in person will also be important from time to time, to ensure that the temptation to take the easy way out, and to produce records for the more difficult sampling sites by guesswork or telepathy, is detected and dealt with severely.

This approach is probably a reasonable one that should be aimed at by small fisheries departments (see Appendix 1). It will be necessary to supplement this approach by the steady monitoring of routine data from a limited number of locations as suggested in the previous section (see also Appendix 3). A wide variety of types of data are needed.

6. CATEGORIES OF INFORMATION REQUIRED FOR DIFFERENT TYPES OF ANALYSES

Appendix 2 provides an introduction to some types of recording forms for the collection of fishery data for a variety of purposes in the fisheries sector. A wide variety of types of data for a range of different analyses are required from time to time in the fisheries sector, and although this publication can only touch lightly on each of these, it is useful to take a broad perspective on the likely information needs early on in planning a statistical data base, to avoid having an excess of information on one aspect at the expense of a complete lack of data on other aspects.

6.1 Type and Quantity of Catches and Landings

The main types of commercial landings need to be categorized and properly codified at the preparatory stage of planning a statistical system. Each category will require a somewhat different approach to sampling and some will contain a variety of species or commercial classes that need recording separately. Some typical categories recommended to the Commonwealth of the Bahamas (Caddy 1981) were:

(i) live fish (held in live wells) and sold piecemeal,

(ii) whole iced fish landed in boxes,

(iii) frozen fish or crawfish tails in "40-lb" bags,

(iv) fish fillets frozen in bags,

(v) conch (in shell, shucked before sale).

Similar categories have to be chosen for each island (group) that reflect the different types of resource locally available and important for data collection. These categories each need to be sampled for sizes, ages and species composition in order to adjust up to the total landing estimated for the main species of concern.

The various approaches to estimating total catch from a fishery and the consequent level of landings are given in Bazigos (1974) and FAO (1981). Two approaches are commonly used:

(a) find the total catch from a known fraction of all fishing operations for which catch figures are known. As noted later, this is only possible if the entire sampling frame has been defined, and sampling carried out randomly;

(b) attempt to reach all sales transactions going through fish processing plants and authorized buyers by a scheme such as that given in Appendix 3 (a Census Approach).

6.2 Conversion Factors

The above example indicates one of the special problems found in many fisheries; the spiny lobster from spear fisheries are likely to be butchered at sea, and only tails landed. This may or may not be the case for the trap fishery. If not, then carapace length may be available for one fishery and tail lengths only for the other. Similar problems will be found in combining gutted or dried weights of fish with fresh weights in estimating total fish landings. For such conversions, a conversion factor will be needed for each processed type to express it in terms of the conventional measurement adopted: usually either total or carapace length, or whole fresh weight. Conversion factors can be established by measuring/weighing a sample of some 200 labelled individuals of the full range of sizes before processing them in a commercial fashion, and reweighing and remeasuring them afterwards. Conversion factors can then be obtained by regression analysis (see FAO (1980) for more details). This is time consuming, but only needs repeating when commercial methods of treatment change.

6.3 Main Types of Gear/Vessel in Use

Especially for biological sampling, it is important that the fishing gear category be reflected on the sampling forms. Some typical categories for the Bahamas were:

(i) spear fishing (crawfish tails, whole or filleted fish),

(ii) handlines (whole or filleted fish),

(iii) seines (whole or filleted fish),

(iv) traps (crawfish tails, whole or filleted fish),

(v) bully nets (crawfish tails).

Obviously, again, these categories have to be adjusted to local practice and properly codified.

6.4 Identity of the Resource

Prior to setting up a sampling or monitoring scheme for resource assessment purposes, it is necessary to establish what are the species groups being fished before deciding on meaningful resource categories.

(1) Species identification: proper species identification is a necessary prerequisite to detailed assessment of most resources, and this is a problem faced by most tropical countries where species diversity is high. Identification of fish and invertebrates in the WECAFC area is possible by means of the FAO Species Identification Sheets (see e.g., fishing area 31: the Western Central Atlantic: Fischer, 1978). For actual identification of fish in landings it is of course impractical for the statistical worker to carry with him a 7-volume compilation including of the order of 1 000 potential and actually commercial species. In fact, the situation is usually made more manageable by first extracting those sheets for species of commercial importance by the country in question. The situation is simplified for several of the more important species (e.g., lobster, conch in the Caribbean) where identification is not usually a problem. For several others, especially the trap fishery for reef fish, these are often sold in mixed form after removal of species of high price; as such, their individual categorization may not be a top priority, i.e., a category such as "mixed reef fish" may be necessary. Alternatively, or in addition, one or two key species of reef fish that are easily recognizable, may be selected for statistical sampling as "indicators" of the state of reef resources. Someone familiar with the resources of the area and their commercial categorization will need to design a simple "guide to the commercial fisheries" based on the FAO Identification Sheets, and an appropriate sampling form

(e.g., forms F and G in Appendix 2) for each subregion (where possible, coordinating this between adjacent island states).

(2) Data on species composition: Market surveys at regular annual intervals are useful to note the proportion of the key species being offered for sale, and their relative prices, and can offer indirect evidence of changes in relative abundance of species, since the price of "substitute" or former "trash" species tends to rise as the preferred species become less abundant and too expensive for most consumers. For a more accurate idea of species composition, sampling at landing points is the recommended approach, or if discarding at sea is the case (it usually is) at sea sampling on commercial boats will be needed.

(3) Stock identity: In resource assessment, it is important first to consider what are the "unit resources" or stocks of a given species that are being exploited, and design the statistical system in such a way that information from different unit resources can be separated. For example, while it may be reasonable and appropriate to consider managing all of the coral reef resources of a small island as a unit, in the case of two systems of coral reefs separated by a considerable distance, it may be more appropriate to treat the fish stocks of these two reefs as individual resources.

On the contrary, for migratory, especially small neritic pelagic resources, (e.g., herring anchovies), the stock of a series of islands sharing a common shelf will need to be managed in a unit. For oceanic species (e.g., tuna, flying fish), it is likely that the islands of an archipelago will be sharing a common resource, even if there is not a common shelf together with fisheries from adjacent continental areas. Some of the problems in dealing with these types of common resources are advanced in Gulland (1981) and Caddy (1982), but from the point of view of assessment of these last two types of resources, it is important that all data from a unit stock be considered together, and kept separate from adjacent stocks.

6.5 Direct Approaches to Fishery Assessment: Mapping and Surveying Shelf Resources

The direct approach to estimating the potential productivity of island shelves is to construct a map of shelf habitats (reef, sand, mangrove, turtle grass, and mud, etc.), stratified by depth, and use this as the basis for a resource survey to determine the overall biomass of different commercial species, or of the resource as a whole (a multispecies assessment), using either a research or chartered commercial vessel.

The funds and personnel to carry out a proper resource survey may not always be available, and a map of the main habitats and fishing grounds may have to be constructed from interviews with fishermen, or in more detail, from LANDSTAT images and aerial photographs (see Caddy and Piaggesi (1982) for details of the methodology).

As discussed earlier, thematic maps, however simple, allow fishing grounds to be outlined and their area estimated by planimeter. The population biomass for a species is then given by (area of grounds x average biomass per unit area). A first rough estimate of potential yield from this biomass requires for each species a knowledge of the fishing mortality rate F (given by fishing yield/average biomass) and natural mortality rate (M), which is obtained from biological research, or by using the value obtained for the same species in adjacent areas. The yield tables of Beverton and Holt (1966) can then be used to estimate what will be the level of fishing and size at first capture that gives the maximum yield per recruit.

6.6 Indirect Approaches to Resource Analyses

Estimating the potential yield from a resource indirectly by analysis of commercial data collected, supplemented of course by information on the biology plus distribution of the resource, is the indirect approach to estimating potential productivity. This approach should however, be the main one adopted when the resource is at, or close to, the maximum yield, since it permits modelling of the relationship between fishing effort and the yield and economic return from fishing in a way that it is difficult or impossible to do from surveys alone. In any case, this is less expensive and also provides information for analysing the economic performance of the fishery. This is not to minimize the importance of resource surveys, but for smaller island countries these need only be carried out at longer (e.g., three to five-year) intervals, except in special circumstances, if statistics are being collected and analysed.

6.7 Catch and Effort Analyses

It is important and basic to nearly all types of assessment, that administrators have a knowledge of the total catch of a given species category, or at least an indication of trends in the levels of landings. This information can be obtained in a number of ways (and these categories generally apply for other types of information discussed later).

(1) Total landings: a full-coverage system which may be a cost-effective approach to collecting landing data (as an alternative to a continuously operating and costly sampling surveys) is the use of compulsory sales slips for those resources passing through accredited fish dealers and merchants. Such a scheme is outlined in Appendix 3 and will need to be modified in the light of local conditions. This scheme has obvious attraction in cases where resources are sold through middlemen. It is also of value when a valuable resource is exhausted and overfished, and should be under strict resource conservation to allow stock recovery (e.g., lobster, conch). Under these circumstances, licensing of a limited group of fishermen, or the granting of territorial use rights (TURFS) (Christy, 1982) will be necesary to ensure stock recovery. Counter indications for the use of a full coverage system is where there are many and diffused landing sites, a high proportion of bartering or direct sales to consumers, a low degree of literacy of vendors or if little surveillance is possible.

Statistically, the main problem with the data collected from this approach is a significant chance of bias (e.g., consistent under-reporting), and the role of the experienced fishery officers here is to estimate from other sources, what are the likely magnitudes of landings not being reported this way.

The other main alternative to estimating total landings and effort (especially for day boats) is to determine the mean catch rate for a given resource, and to obtain an estimate of total landings by combining the results of the fisheries survey (estimation of the effective fleet size using an up-to-date boat registry), plus special information on the average number of days fished per survey period by boat from a given gear on a given type of resource.

For a given uniform type of vessel and fishing method, the landings in a month J of species A on a given ground can then be obtained from:

$$\begin{array}{lccccc} & & \text{(a)} & & \text{(b)} & & \text{(c)} \\ \text{Total landings of species A in month J} & = & \left[\begin{array}{l}\text{Mean catch/}\\ \text{boat/day of}\\ \text{species A}\end{array}\right] & \times & \left[\begin{array}{l}\text{No boats}\\ \text{actively}\\ \text{fishing}\\ \text{for A}\end{array}\right] & \times & \left[\begin{array}{l}\text{Mean number of}\\ \text{days fished/}\\ \text{boat/month}\end{array}\right] \end{array}$$

Types of information (a) and (c) come from interviews with fishermen or company records, (b) by combining the results of a fisheries survey (estimation of the coefficient of fishing activity) with an actively maintained boat registry. Monthly landings by community can be added by vessel type and month to give annual, regional, or national totals as required. Care will have to be taken that the vessels picked as typical of a given class are not those likely to have a higher catch rate than average. In replacing one individual fishing boat with another, it is desirable to replace it with another with a similar performance.

(2) Fishing effort: given one or more uniform boat types fishing the same fishing gear, one category can be chosen as standard, and the total effort exerted by all vessel categories per month can be obtained from an estimate of its landings per month, as follows:

$$\text{Fishing effort in units of vessel type (1)} = \frac{\text{Total catch (all vessel types)}}{\text{mean catch/boat/day (type 1)}}$$

This figure can be obtained either for a given resource A, or for the whole (multi-species) resource, and of course added over communities and months to give annual figures.

6.8 Size Frequency and Age Composition Data

The size range of a species being landed in a given area is a sensitive indicator of events happening to the resource. Thus, a decline in mean size in the catch with an accompanying drop in catch rate is usually an indicator of overfishing, while if accompanied by an increase in catch rate of juveniles, it will be a good indication that better than average recruitment (compared with recent years) is occurring. Conversely, an increase in mean size and catch rate may indicate that effective effort has declined in recent years; however, if accompanied by a decline in catch rate, it may indicate that recruitment levels have declined to lower than average levels.

The distribution of size in a population is a function of its age composition, its growth rate and of the mortality rates exerted on it by natural causes and by fishing. All of these rates can be estimated from carefully planned sampling procedures, and accompanying biological information. Although the classical approach has been to combine sampling for sizes with an age-reading function to determine growth and mortality rates directly (e.g., Holden and Raitt, 1974), there are now a variety of methods (see Jones, 1985; Pauly, 1982) to estimate those important parameters directly from the size frequencies. Although these approaches require a good understanding of the methods being used, they provide most of the basic information needed for fish population analysis other than catch rate and landings.

The approach to data gathering most suited for entering reliable estimates of population parameters from size frequency data, is sufficiently time-consuming that it would be advisable to concentrate for the first few years on a maximum of half a dozen species of particular interest that are in need of conservation. The importance of avoiding mixing similar species in this type of work must be emphasized. Good initial candidates for sampling for size frequencies in the Caribbean are:

Species	Measurement	Special features to note
(1) Spiny lobster	(carapace length)	- record separately by sex
(2) Conch	(shell height)	- record thick and thin-lipped shells separately

Plus, fisheries consisting predominantly of one species, e.g.:

	Total length
(3) Flying fish	"
(4) King mackerel or dolphin	"

and reef fish, e.g.:

(5) Grouper, goat fish or known species of reef fish (e.g., parrot fish).

Other species, or groups of species will have to be priorized for other areas.

Sampling should be for all major gear types capturing the species in question, weighted by the proportion of the total catch they constitute. Ideally, small samples from a larger number of sources is much preferable to measurement of the same number of individuals from one large catch. Thus, if the fleet catching spiny lobster consists of:

(a) 12 boats trap-fishing, each taking roughly 100 kgs/day, and fishing 10 days/month (i.e., 12 x 100 x 10 kgs = 12 000 kgs/month);

(b) 8 boats, spear-fishing, each taking roughly 50 kgs/day and fishing 15 days/month (i.e., 8 x 50 x 15 kgs = 6 000 kgs/month).

Then say, a total of 10 boxes of 50 kgs each of lobsters should be measured from 5 to 10 of the trap-fishing boats, and 1 box from each of 5 of the spear-fishing boats per month; before beginning to combine the size frequencies to obtain monthly or fortnightly totals.

Although not required for all analyses, size frequencies can be "weighted up" to give the estimated size composition for the whole monthly commercial catch of 18 000 kgs. This is done, size category by size category, as follows (for example, the spiny lobster length group 75-80 mm carapace length):

Trap

$$\text{Total number of 75-80 mm lobster in catch} = \left[\frac{12\,000}{10 \times 50}\right] \times \left[\begin{array}{c}\text{No 75-80 mm}\\ \text{measured}\end{array}\right] + \left[\frac{6\,000}{5 \times 50}\right] \times \left[\begin{array}{c}\text{No 75-80 mm}\\ \text{measured}\end{array}\right]$$

An illustration of this procedure is given in Figure 3 for a fishery having three gear categories. Over a period of a minimum of one year, regular samples of a species integrate over gear type in the above fashion should permit estimates to be made of growth and mortality rates.

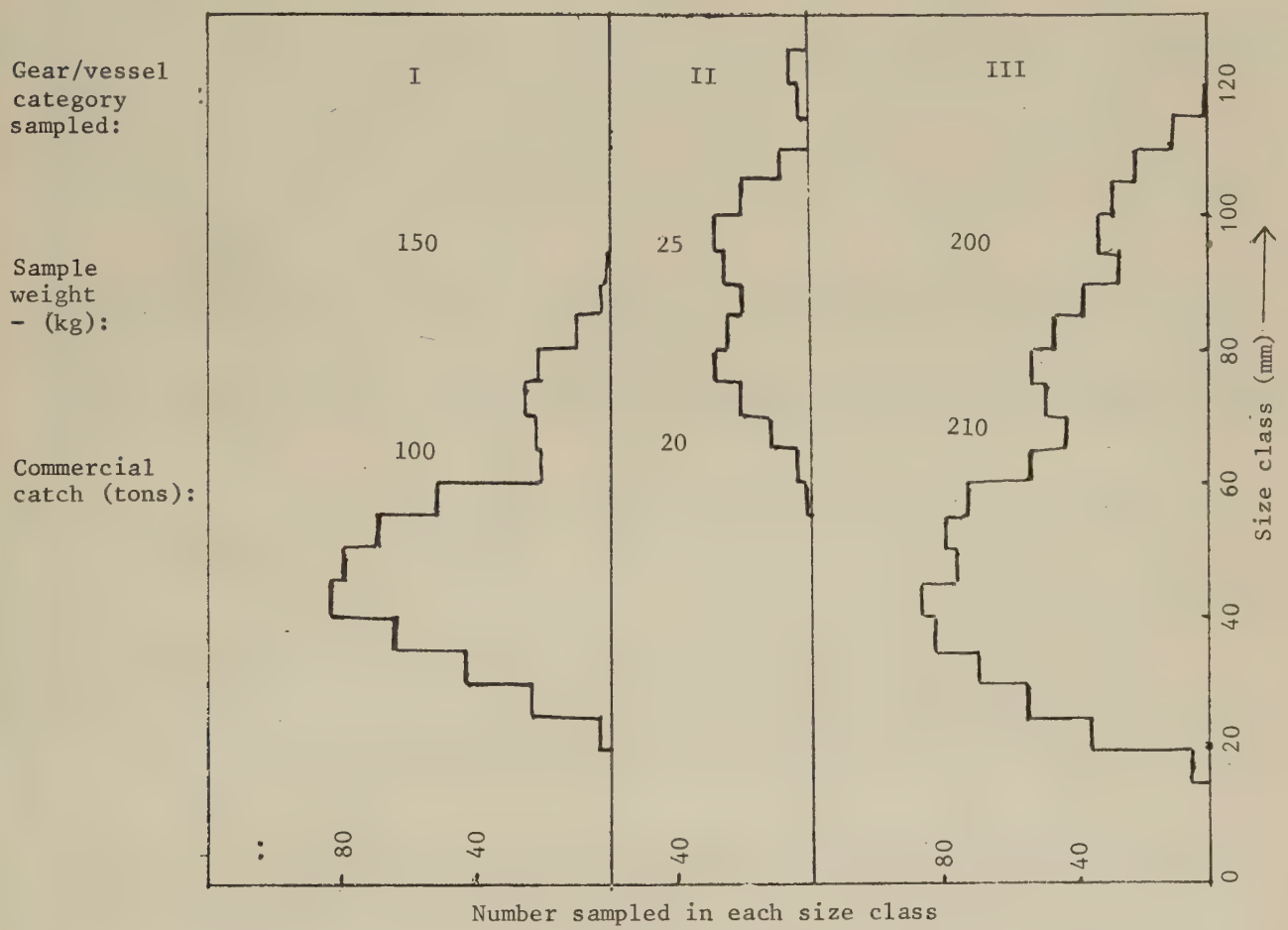

Figure 3a Monthly size frequencies from sampling 3 commercial gear/vessel categories

Where:

$A_{i\ell}$ = Number per size group ℓ measured from gear i.

B_i = Sample weight (gear i) in kg.

C_i = Weight caught in time interval (kg) by gear i.

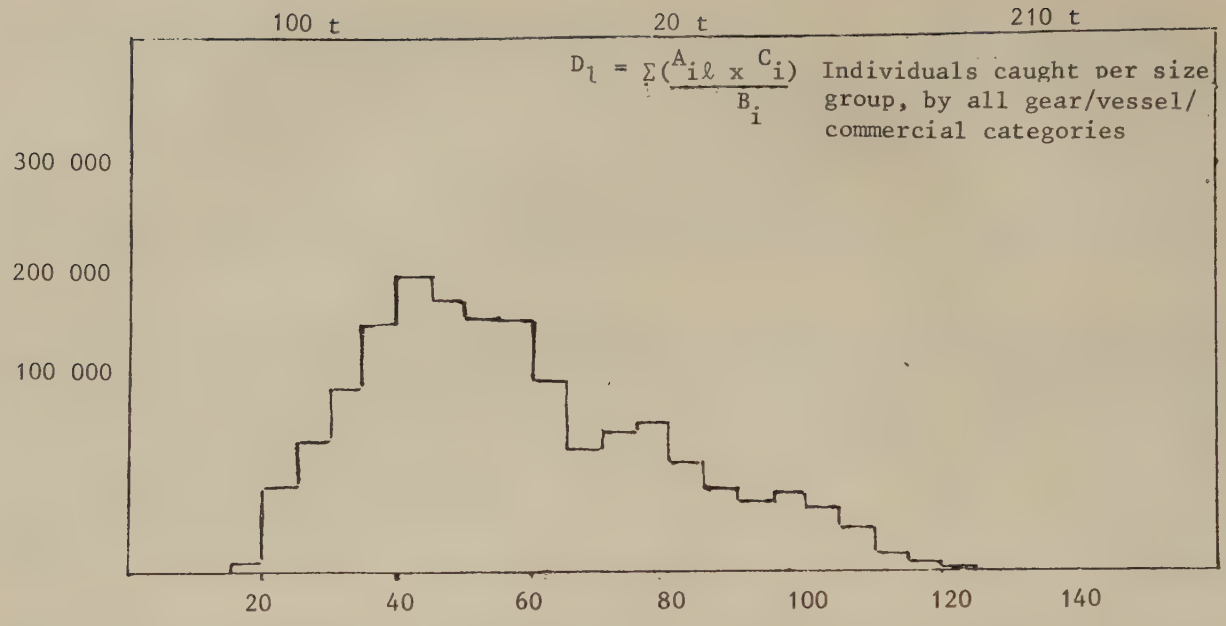

Figure 3b Overall monthly size frequency (all gear)

In certain fisheries supplying fish processing plants, it may be possible to obtain data on commercial size categories which can be used to save a great deal of effort in obtaining the overall size frequency, if they can be made available. Thus, if three commercial categories for which known weights have processed, the overall size frequency can be obtained by sampling each size category separately, they can be combined as described above for the separate commercial categories.

7. COMPILATION, FILLING, RETRIEVAL AND ANALYSIS OF DATA

A broad plan covering the need for all types of statistical data from resources studies to socio-economics and planning should be prepared. Five stages may be recognized in the compilation of fishery data:

(i) transfer of primary data on field sheets to summary sheets, or in the case of computer records, punching the data onto cards or directly onto discs or tapes;

(ii) checking the basic data for errors of transfer and gross recording errors (in the case of computer punched data, this can in part be done by appropriate automatic checking routines);

(iii) weighting up samples to total landings by day, port, month and region as needed and preparation of summaries of data by different sub-categories (e.g., catch and effort separately by gear type, area, species, time or any combination of them). Here, the great advantage of computerization lies - rounding and other errors are minimized, as well as much time and effort saved;

(iv) analysis of the data to provide conclusions as to (e.g.,) the state of the resources, total exports of fish etc. Some time and thought should also be devoted at an early date to the likely needs for future data analyses, even if personnel are not yet available to make full use of it.

(v) filing and retrieval of data on a way that allows it to be easily retrievable and revised. The use of a large-scale map of the sampling frame, cross referenced to the appropriate file in the storage cabinets, allows them to be updated as new information becomes available. Files should be kept for each landing point, listed and categorized, and separate, but cross-referenced files, should be kept also on the principal fish species landed, and on the main fishing grounds/stocks.

This publication has not developed at great length on the technical aspects of calculation, magnitudes/variances etc, which can be more readily obtained from a standard text book (e.g. Steel and Torrie, 1960), but a brief summary of some of the key concepts is provided in Appendix 4.

The use of a microcomputer for summarizing and analysing data forecasts has advantages for even moderate-sized fisheries departments. The priority in small departments is, however, for actually collecting data, and time spent on learning to operate and use these computer facilities cannot be allowed to detract from this primary function. This kind of equipment can therefore only be justified if it frees individuals from clerical work to actually go in the field and collect data. The advantages here of having some regional organizations whose responsibility is preparing regular data and summaries by computer is evident here, or alternatively, a centralized statistician/programmer working for several government departments in smaller island states.

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APPENDIX 1

A Statistical Procedure for Continuous Collection of Fishery Data Using a Restricted Number of Recorders

In this Appendix we discuss the operational and technical aspects of a simple survey system for the collection of catch and effort data on an ongoing basis. There are four main stages in the implementation of a Catch Assessment Survey (CAS):

1. Planning the survey
2. Designing the survey
3. Field operations for data collection
4. Processing and presentation of the results

Another stage which should be added up is the one dealing with the analysis and reporting on the estimates calculated.

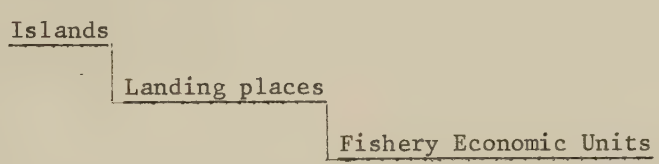
1. Planning the Survey

At the planning stage of a CAS the questions that require consideration are:

(a) The scope of the survey must be clearly specified, i.e., should the survey be aimed at one objective (by resources or fish consumption) or should it be multi-purpose in character aimed at satisfying the needs of a variety of users such as planners, economists, fishery scientists? If the latter, so, their individual requirements be taken into account to the extent possible within manpower and financial constraints.

(b) The geographical coverage of the survey (traditional-artisanal fisheries, industrial fisheries) must be defined.

(c) The hierarchy of units in the population must be defined. In the case of traditional and artisanal fisheries the following hierarchy of units can usually be identified:



(d) Decision must be made on the nature of information to be collected, and an efficient coding system for species, vessels, gear, fishermen and effort units must be prepared.

(e) The required source documents for data collection, i.e., lists, questionnaires, mapping material and other supporting documents must be prepared.

(f) A decision must be made on the method of data collection, e.g., census survey, sample survey, and of the method of obtaining the information, i.e., by interview, by objective measurements made by the officer at landing places, etc.

(g) A frame survey must be conducted and the appropriate sampling frame must be constructed providing information of the basic characteristics by sampling units.

2. Sampling Design for Small-Scale Fisheries

Catch Assessment Surveys of traditional and artisanal fisheries are based on sample surveys "sampling in space and time". As far as space is concerned the decision to be taken is on the number of landing places to be selected within each island for data collection. As far as time is concerned, the decision to be taken is on the number of survey-days to be allocated to each sample landing place. It should be noted that CAS are "cost-oriented" surveys and that decisions concerning the sizes of the samples (space, time) should be made, taking into account available resources.

(a) Calculation of sample sizes

Assume that within an island transport is not a problem and that recorders can move from one landing place to another, and assume as a simple example, that there are 24 landing places on the island, of which 4 are the most important ones. A "working group" of two recorders is assigned for data collection on a monthly basis. Steps to be taken for the calculation of the sample sizes are:

(i) Calculation of the time available Z, which is given by:

Z = number of recorders (2) x working days per month (20) = 40 (recorder-days)

(ii) How many samples?

One reasonable approach is to use the census method in space (complete coverage) for the most important landing places (= 4) and the sample method in space for the remaining landing places (= 24 - 4 = 20). Also, it is reasonable to allocate more survey days to the most important landing places than to the remainder. For example, the choice might be six survey days to be allocated for each important landing place, and three survey days to be allocated for each landing place of secondary importance. In such a case, the sample size of secondary landing places is:

$$n_2 = \frac{(40 - 4 \times 6)}{3} = \frac{16}{3} \simeq 5 \text{ landing places (LP's)}$$

where:

40: total number of recorder-days per month
24: total number of recorder-days allocated to the important landing places
16: total number of recorder-days allocated to the secondary landing places
3: number of survey recorder-days allocated per secondary landing place.

The composition of the overall sample sizes are:

	Space	Time
Important LP's:	$n_1 = 4$ (out of $N_1 = 4$)	Survey days per LP: 6 per month
Other LP's:	$n_2 = 5$ (out of $N_2 = 16$)	Survey days per LP: 3 days per month

It should be noted that the above sampling scheme introduces a kind of stratification into the sampling process, i.e.:

Str. 1: large LP's ($N_1 = 4$)

Str. 2: other LP's ($N_2 = 16$)

Monthly estimates of the survey magnitudes are first calculated on a stratum basis. Total monthly estimates for the island as a whole are calculated by adding up the strata estimates. Total monthly estimates for the population as a whole, say, consisting of 3 islands, are calculated by adding up the monthly estimates of the individual islands.

(b) Sampling within the sample LP's

Within the sample landing places, items of information from the boat-landings are usually obtained on a sample basis. Specifically, a few boat-landings are selected from the total landings within a survey day for data collection. If there is more than one main fishery operating, a number of sample survey days are allocated to each of them. Steps to be taken:

Three distinct magnitudes:

For each sample day, data must be recorded on to the following three distinct magnitudes:

(i) total number of fishing boats operating by type of fishery (N_f);

(ii) total number of boat-landings of the fishery surveyed (M_f);

(iii) sample size of selected landings of the survey fishery (m_f).

The list below (List 1) portrays the format of the document needed for the collection of the required information on N_f, M_f and m_f, on a daily basis within the selected landing places. Specifically, in the preparation of List 1, the assumption is made that two fisheries are operating at the sample landing place which belongs to Stratum 1.

List 1

Island:

Year:
Month:

Note: We assume that:
- there are two main fisheries operating, A and B
- three survey days were allocated to fishery A (i.e., 1, 2, 3 days) and three survey days to fishery B (i.e., 4, 5, 6 days)

Str: (say 1)
Landing Place: (name)
C.No.:

Survey day		Fishery A					Fishery B				
Date	C.No.	N_f A:	N_f (B:)	M_f	m_f	Completed questionnaires					
	1	20	(15)	10	5	5					
	2	20	(15)	8	4	4					
	3	20	(15)	12	6	6					
							(A)	N_f B	Mf	m_f	Completed questionnaire
	4						(20)	15	12	6	6
	5						(20)	15	10	5	5
	6						(20)	15	8	4	4

(c) Completed questionnaires

For each selected boat-landing a questionnaire will be completed providing the required items of information. A code number consisting of 5 digits identifies the completed questionnaire plus the survey date:

Survey date	Year	Month	Day
	☐☐	☐☐	☐☐

Landing Place C.No.

1, 2, 3 Island's code No. ☐

1, 2 Stratum No. ☐

1, 2.. Sample landing place number ☐

01, 02,. Sample number of selected boat-landing ☐☐

(d) Raising sample data to the population total

For each item of information included in the completed questionnaires, monthly estimates can be calculated by fisheries using the proper raising factors:

Str: 1 - In our example, there are four landing places in Str. 1. The census method in space (complete enumeration of landing places) was used for data collection. As far as time is concerned, three days were allocated to each fishery within a sample landing place for obtaining the required information. The following steps should be taken for obtaining Stratum monthly estimates for a given characteristic, say total fish catch (variable - y) and for the given fishery (fishery - f).

Steps: Estimated monthly totals within each sample landing place

(i) pool the completed questionnaires of the three sample days together;

(ii) add up the values of the characteristic total fish catch, which have been recorded in the individual questionnaires, say, sample total value - A;

(iii) multiply A by the following ratio:

$$R_1 = \frac{\text{Total number of landings in 3 days}}{\text{sample number of landings in 3 days}}$$

$$\text{i.e., } B = R_1 A$$

Note: the required data for the calculation of R_1 value are given in List 1.

(iv) multiply B by the time-raising factor

$$R_2 = \frac{\text{Total number of fishing days in the month}}{\text{Sample fishing days (=3)}}$$

$$\text{i.e., } C = R_2 B$$

Magnitude C expresses total monthly catches within a given sample landing place and for the given fishery.

Monthly stratum estimates

Monthly stratum estimates are simply calculated by adding up the calculated monthly estimates of the individual landing places (remember, in Stratum 1 our survey system is based on the census method, i.e., a complete coverage of all landing places) i.e.:

$$_1C = C_1 + C_2 + C_3 + C_4$$

where: $_1C$ = total monthly catches in Str. 1.

Str. 2 - For the estimation of monthly stratum totals in Stratum 2 the following steps should be taken:

Estimate monthly totals within each sample landing place

Follow exactly the same operational steps (i) to (iv) described above, i.e., Stratum 1.

Monthly stratum estimates - Steps:

(i) add up the monthly estimates which were calculated for each sample landing place:

$$_2C = C_1 + C_2 + C_3 + C_4 + C_5$$

(ii) multiply $_2C$ by the stratum-raising factor, R_3 = total number of operating fishing boats in the stratum of the given fishery (frame data) divided by the total number of operating fishing boats in the sample landing places, i.e.:

$$_2E = R_3\ {}_2C$$

Where: $_2E$ = total monthly catches in Str. 2.

Overall monthly estimates for the island as a whole are calculated by adding the strata totals:

$$Y = {}_1C + {}_2E$$

Yearly estimates are calculated by adding up the monthly estimates.

If the survey population consists of more than one island, monthly estimates are first calculated on an island basis. Overall monthly estimates for the population as a whole are calculated by adding up the individual estimates.

(e) Estimations

Note: This section should be ommitted by the readers not having a mathematical background.

The operational steps described above for the calculation of estimates of the survey magnitudes can be presented in a concise form by using the proper symbols and formulae:

Suffixes

h: a given island in the survey population (h = 1, 2, ..)
1: the strata of landing places
i: the i-th landing place (i = 1, 2, ..)
f: a given fishery (f = 1, 2, ..)
j: a given boat-landing (j = 1, 2, ..)
d: days (d = 1, 2, ..)
$\Sigma(d)$: survey days

Symbols

$_h N_1$: total number of landing places within the 1-th stratum in the h-th island

$_h n_1$: selected landing places within the 1-th stratum in the h-th island

$_h W_{1f}$: total number of fishing boats of f-fishery, in the 1-th stratum in the h-th island

$_h w_{1fi}$: total number of fishing boats of f-fishery in the i-th landing place, etc.

$_h M_{1fid}$: total landings on the d-th sample day, etc.

$_h m_{1fid}$: selected landings on the d-th sample day, etc.

D: total fishing days in a given month

Σ: scummator

Estimators (= formulae) - monthly estimates

(a) Estimated monthly total, say, catches in Stratum-l = 1, in the h-th island:

$$\hat{Y}_{1\ell f} = \sum_{i=1}^{h N_{1f}} \frac{D}{\Sigma(d)} \frac{\sum_d {}_h M_{1fid}}{\sum_d {}_h m_{1fid}} \sum_{d} \sum_{j=1}^{h m_{1fid}} {}_h y_{1fidj}$$

(b) Estimated monthly total, say, catches in Stratum 1 = 2, in the h-th island:

$$_h\hat{Y}_{\ell f} = \frac{{}_h W_{1f}}{{}_h w_{1f}} \sum_{i=1}^{h n_1} \frac{D}{\Sigma(d)} \frac{\sum_d {}_h M_{1fid}}{\sum_d {}_h m_{1fid}} \sum_{d} \sum_{j=1}^{h m_{1fid}} {}_h y_{1fidj}$$

(c) Estimated monthly total, say, catches for the island as a whole:

$$\hat{Y}_{hf} = \sum_{l=1}^{2} \hat{Y}_{lhf}$$

(d) Estimated monthly total, say, catches for the population as a whole:

$$\hat{Y}_{f} = \sum_{h} \hat{Y}_{hf}$$

(e) Yearly totals are estimated by adding up the monthly estimates.

3. Field Operations for Data Collection

The main task of the field recorders is the collection of the required information by following the instructions and procedures spelt out in the design of the survey. They keep to a detailed "timetable" of their activities and of the time allocated to each of them.

The landings of the sample units surveyed are sorted out by species or species groups and their weight is taken and recorded. Data fishing effort is obtained by inquiry, and expressed in units appropriate to the fishing unit.

Selection of boat-landings within the sample landing places is made by using systematic sample with a random starting number.

The quality of the raw material obtained and calculated estimates depends among other things, on the magnitude of coverage errors and listing errors, measurement errors, and other kinds of systematic errors inherent in the field operation.

4. Processing of Collected Raw Material

Because CAS of small-scale fisheries are based on sample surveys, processing of the sample data has to be undertaken while taking into account the estimation procedure of the survey.

Processing might be manual by following the simplified procedure portrayed in the previous sections or by using mechanical means, e.g., micro-computers. In the former case, it is advisable to transfer the data from the completed questionnaires to specifically designed "working sheets". As an example, we present the format of a "working sheet" which was used for catch and fishing effort estimates at Tanganyika Lake.

If a decision were taken for the mechanical processing of data, the advice of a specialist (system analyst/programmer) should be requested.

5. Analysis of the Results

Calculated estimates over time can be analysed by using proper statistical techniques. For example, regression techniques can be used for assessing existing relationships between the survey magnitudes. Time series analysis methods can also be used for assessing existing trends underlying the empirical time series and for forecasting purposes.

6. At Sea Observer's Check List

As part of a more detailed monitoring of the fishery, and in order to collect more data on aspects such as discarding that do not show up in port sampling, trained observers should go to sea on commercial vessels on an occasional basis to collect in situ data. Form H is one type of record that can usefully be used for the purpose, after modification to suit local conditions.

LAKE TANGANYIKA FISHERIES RESEARCH AND DEVELOPMENT PROJECT (TANZANIA)
CATCH ASSESSMENT SURVEY (CAS)

a. Round:

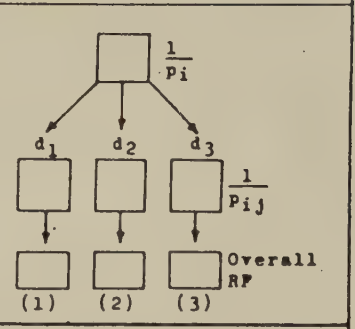
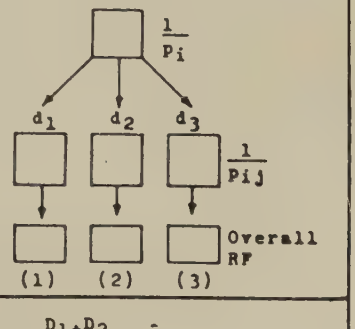
b. Minor Stratum:

c. Fishing method:

d. Characteristic(s):

e. Unit(s) of measurement:

WORKING SHEET 02 (WS:02)
(FISHING EFFORT, FISH CATCH)

Selected fishing site/fishing method (1)	Selected fishermen (2)	Sample day: d_1 (3)	(4)	Sample day: d_2 (5)	(6)	Sample day: d_3 (7)	(8)	$d = d_1 + d_2 + d_3$ (9)	(10)	RAISING FACTORS (11)
□□	01									
	02									
	03									
	04									
	05									
	06									
	07									
	08									
	09									
	10									
	T_1									
	D_1									
□□	01									
	02									
	03									
	04									
	05									
	06									
	07									
	08									
	09									
	10									
	T_2									
	D_2									

Note:

$T_{1,2}$: Sample total of a given variate (sample day basis)

$D_{1,2}$: $T_{1,2}$ x Overall Raising Factor (sample day basis)

f: | |

g: | |

→ $\frac{D_1 + D_2}{2} = \bar{D}$

→ $\bar{T} = c \times \bar{D}$

c = Time Raising Factor

FORM H: AT SEA OBSERVER'S
CHECK SHEET

A. (Complete one for each trip)

Vessel name _____
Date sailed _____
Place landed _____
Observer's name _____
Species sought _____

Skipper _____
Date landed _____
Crew size (m skipper) _____
Size (length) vessel _____
Days fished _____

B. (Complete one each day)

Main fishing gear used _____
Depth _____
Location (Lat. Long. or shore bearings) _____
No. man-hours fished[a/] _____
Hours searching _____

No. traps ☐ divers ☐ dingies ☐
lines ☐ length of seine _____
(check and specify)
Bait (if applicable) _____
Soak time _____
Hours fishing _____

Species caught	Number	Weight	Sample measured (✓)
Crawfish			
Conch			
Barracuda			
King fish			
Rainbow runner			
Grouper			
Snapper			
Jacks			
Grunts			
Turbot			
Others (specify			

Discards:

Estimated weight and species discarded:

species	weight

No. samples measured: (+)

Catch _____

Discards _____

	Location	Description
Other vessels seen fishing: 1.		1.
2.		2.
3.		3.
etc.		etc.

Notes:

a/ For diving, bully net, handline, and snapper reel, multiply hours spent fishing (for diving, hours in the water) times the number of men actually fishing. For seining, specify hours (not man hours) spent searching for schools, and time spent fishing separately. For traps (fish or lobster traps), specify number of trap hauls

(+) Measure at least two samples of catch in course of each day fishing, plus discards.

7. Size Frequency and Age Composition Data

In survey programmes for estimating length composition of the longest species, samples may be purposive i.e., at wholesale markets on random i.e., sampling of commercial catches (see also section 6.8). Specifically, sampling of commercial catches might be based on:

(i) random sampling at landing places;
(ii) on-deck sampling (thus estimating discards)

Random sampling programmes at landing places are based on sub-samples of catches/ landing taken during the main catch assessment survey (CAS). In such a case, weighing factors can be worked out in order to raise the sample data to the population totals.

Examples of the formats used for data collection are given in Forms I and J.

Form J

Example of the type of form needed for collecting data on sampling in 'Weighting up' of measurements of many specimens of the same species to the whole daily catch

Market/Boat:				
Name of fish				
Date				
Name of vessel				
Gear				
Region				
Fishing ground				
Number of categories sorted				
Total catch of each category of this fish, whether sampled or not	Category	Weight caught (kg)	Weight measured (kg)	Otoliths/ scales taken
Categories not sampled				

Remarks

Form I

Length frequency recording sheet

Vessel name

Species name

Vessel code	Cruise number	Station number	Sample number	day	month	year	Minimum length	Maximum length	Length increment	Species code	Stratum code	Total catch kg.	Sample wt. kg.	Raising factor	Sheet number

Length scale cm.

	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	0.0	0.5	1.0	1.5	2.0
*	(1)0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4
+	~~1111~~			111	1		~~1111~~		etc																
S	5			3	1		5		etc																
C																									

	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
S																									
C																									

Key

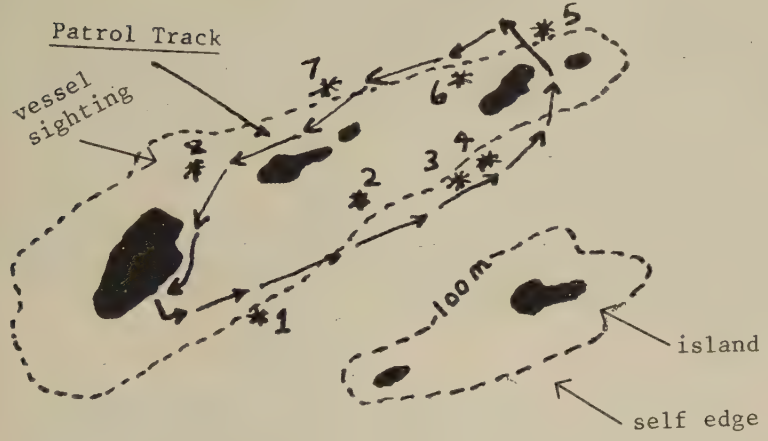
* Add digit before length scale, to adjust the length scale to the size range encountered
\+ Showing method of recording observations
S = Sample total
C = Catch total (after weighing up, using data form J)

8. Observations of Fishing Vessels at Sea

Information on foreign fishing, either legal licensed vessels, joint venture or chartered boat or illegal, may be collected by the Coast Guard or Navy. These arms of government may agree to carry a patrol vessel log, keeping data for use by the Fisheries Department. Form K is an example of a possible format.

FORM K: PATROL VESSEL SIGHTING LOG

(Carbon copy sent to department of fisheries for analysis, original retained by the National Defense Force Vessel)



Date: _____

Vessel: _____

Observer: _____

Time left port: _____

Time returned: _____

(Enter patrol track on map, showing vessels sighted with a cross and numbered in sequence)

Sightings (fill in one for each vessel)

Vessel No.: Comments

Visibility

Distance away (radar___visual sighting___)

Time

Est. position (Lat., Long.,)

Type and size of vessel: (seiner, trawler, longliner, trolley, etc.)

Vessel's name/nationality

Fishing or steaming?

Fishing gear

Vessel No.:

Visibility

Distance away (radar___visual sighting___)

Time

Est. position (lat., long., or___)

Type and size of vessel: (seiner, trawler, longliner, trolley, etc.)

Vessel's name/nationality

Fishing or steaming?

Fishing gear

9. Socio-Economic Statistical Surveys

(a) Cost and Earning Statistical Studies of Fishing Units (CE-S's)

In order to assess the techno-economic and socio-economic performance of various fishing systems, specific statistical surveys are designed and executed within the overall survey system of work using the principle of "integration". Specifically, the survey system of a CE-S is fully integrated with the system of work of the main catch assessment survey (CAS). The integration principle ensures the improvement of the efficiency of the survey, reduction of the overall cost and the improvement of the utility of the results obtained. The main operational steps in which integration is achieved are:

1. Concepts, definitions and classifications are, to the extent possible, made compatible.
2. The organization and field execution of the various components of the surveys are integrated.
3. Sampling integration: Since CAS's are based on stratified two-stage sampling, CE-S's will be considered as partially integrated if they are based on the same Primary Sampling Units (PSU's).
4. The mechanical processing of data is integrated, (e.g., using common code or reference numbers).

CE-S's are multi-purpose in character, in the sense that the results obtained can be used by those responsible for planning and fisheries development programmes, in assessing their economic and social impact, and for management purposes.

(b) CE-S's of Non-Mechanized Fishery Units

In this section we discuss in a summary form, methodological and sampling aspects of a CE-S (small-scale fisheries). It must be emphasized at the very beginning that CE-S's provide only estimates of the average values of the survey magnitudes, i.e., overall mean estimates. This in turn means that the sample data obtained are only used for the estimation of the required mean values e.g., average catch values, average gross revenue values, etc. Consequently, CE-S's are free of the sampling complexities inherent in large-scale fisheries statistical surveys aiming at the estimation of population totals.

In CE-S's the survey subject is the "active" fishing unit. That is to say, the target population is a sub-population of the total population of fishing units. Because of the observed spatial and temporal variations in the number, structure and operational characteristics of the active fishing units, the results of the surveys should be treated with care. Because of the lengthy questionnaire used in the survey for obtaining information on the complete spectrum of the characteristics required, hence, the selection of a small sample of active fishing units for cost-oriented surveys, the number of samples, and hence the statistical power of the calculated estimates is not very high. Another problem which affects the results of the survey, is the "non-response" rate observed, which effects the generality of the data, and the level of quality of the information obtained.

The sample design of a CE-S is based on stratified two-stage sampling. As far as the PSU's is concerned, the sample of a CE-S is a sub-sample of a sample unit of the main (integrated) CAS. The method of post-stratification is used within the sample PSU's for the selection of the sample of fishing units. Specifically, active fishing units are grouped into domains by using a hierarchy of criteria for stratification, e.g.,

1. Fisheries
2. Kind and size of fishing craft and gear
3. Importance of fishing units expressed in terms of capital investment or number of units of gear used.
4. etc.

A sample of fishing units is selected within some (or all) domains of interest for data collection. The selected units sampled are kept fixed over time, and the required items of information are collected from these sample fishing units over a number of successive occasions e.g., monthly, for a duration of at least one year. Final decision on one sampling process requires a detailed study of the overall survey system.

Sampling in time could also be introduced in the process of data collection. For example, for dynamic characteristics, e.g., trends or fluctuations in levels of catches, effort, etc. data can either be collected on a daily basis for the whole reference period, of say, a month (census in time) or for a chosen sample period, say, a week within the reference period (sample in time).

A proper codification system should be developed, to economically describe port and area fished, date, time, fishing units and their characteristics, and this should be introduced during the design of the survey. This simplifies mechanical processing, and presentation and analysis of the sample data.

Usually the same statistical recorders carrying out the CAS are also used for data collection in the catch and earnings survey. Extra time is allocated to them for the additional field operations required.

Either the book-keeping method or interview method can be used for obtaining the required information. For small-scale fisheries the interview method is usual. The book-keeping approach needs literacy and good cooperation by the fishermen; it is associated with a high non-response rate.

The items of information which may be obtained by a CE-S of non-mechanized fishing units can be grouped under the following headings:

1. Gross earnings
2. Fixed costs
   - (i) insurance
   - (ii) depreciation
   - (iii) interest
3. Total operating costs

A. Owner operating costs
   - (i) repair and maintenance of craft
   - (ii) repair and maintenance of the gear
   - (iii) food
   - (iv) material
   - (v) ice, salt, power, water
   - (vi) crew share
   - (vii) others

B. Common operating costs
   - (i) food
   - (ii) traditional taxes and offerings
   - (iii) materials
   - (iv) commission
   - (v) repair of craft and gear
   - (vi) renumeration to other owners.
   - (vii) repayment of loans
   - (viii) others

4. Renumeration to crew in cash
5. Renumeration to others in kind, in cash
6. Net profit.

An example of the format of the questionnaire used for non-mechanized fishing units is shown in Form L, from Kurien and Willmann (1982).

(c) CE-S's of Mechanized Fishing Units

Catch and earnings surveys of mechanized fishing units, have often been concentrated particularly on trawl fisheries, which are not always of great importance to small island fisheries. However, as with the other sample forms shown, Form M should be modified in the light of local conditions while preserving, to the extent possible, the main categories of information. The main objective of the surveys is to estimate the productivity and profitability of selected fisheries, for management purposes.

APPENDIX 2

Surveys and Source Documents in Selected Fields

Introduction

This Appendix deals with the questionnaires and source documents used in collecting various types of fishery-related data. These forms should be modified in the light of special requirements and local conditions, and are largely intended to assist in the planning of surveys for a number of specialized purposes. A description of the disciplines and analyses for which the data collected on these forms are intended is beyond the scope of the present document, nor is it our intention to give priorities to the various discipline involved. It would be advisable before beginning full-scale use of one or other of the forms, particularly since a statistical survey design needs to be established, to seek advice from an expert in the field in question. Despite this proviso, the potential use of the type of forms included in this Appendix, and the types of information they are designed to record, have an obvious utility to anyone involved in the field of fisheries, and can be employed after local modification for information collection of an indicative kind, or for small-scale sample surveys prior to a full scale survey.

It should be borne in mind that although useful information can be accummulated by non-systematic data collecting, the basic principle applies that unless a census approach is adopted (all units sampled for all operations) which is usually impossible, valid conclusions having a known order of accuracy will depend on following some form of representative sampling. Thus, a known framework of sampling units which should be random at base, in order to avoid biases entering the data which of course, will also emerge in the analysis of results.

The main types of form included in the Appendix cover the following activities:

a. Fish production surveys:

FORM A: Frame surveys of traditional and artisanal fisheries.

FORM B: Aerial frame survey: traditional and artisanal fisheries (direct counting)

FORM C: Inventory of industrial fishing craft characteristics

FORM D: Masterlist of industrial fishing vessels

b. Catch and effort statistics: (logbooks and observer's vessel sheets)

FORM F: Marine fisheries production survey: (1) Logbook for trawlers

FORM G: Marine fisheries production survey: (2) Logbook for purse seiners and/or gillnetters

FORM H: At sea observer's check sheet (see page 28)

c. Size frequency data

FORM I: Length frequency recording sheet. (See page 30)

FORM J: Form for "weighting up" of measurements of many specimens from a limited sample to the whole day's catch. (See page 29)

d. Observations of fishing vessels at sea:

FORM K: Patrol vessel sighting log. (See page 31)

e. Socio-economic statistical surveys

FORM L: Cost and earnings survey of fishing craft and gear (especially non-mechanized craft).

FORM M: Cost and earnings survey (especially mechanized craft).

FORM N: Economics survey of fishing boats: questionnaire for owners.

f. Breakdown of operating time during fishing

FORM O: Time and motion study of fishing operation.

g. Household surveys and fish consumption

FORM P: Inventory of fishing households and fish consumption.

FORM Q: Sports fishing catch survey.

FORM A: FRAME SURVEY
OF TRADITIONAL AND ARTISANAL FISHERIES
(COMPOUND APPROACH)

Form [1][1]
(a) stratrum [ ][ ]
(b) island [ ][ ]

(c) Working team: [ ]

(d) Survey period: [ ][ ][ ][ ][ ][ ] - [ ][ ][ ][ ][ ][ ]

Map Coordinate Nos.	1. Cluster (c) unit (e.g. small port 1, large port 2, landing beach 3)				2. Fishing units by type			3. No. of fishing vessels by type									4. Landing and fishing habits (see col-6)			5. Disposal of fish	6. Facilities (1. refrigerator, 2. cold store, etc.)	Remarks
					Type			1. Motorized					2. Non-motorized									
	Locality serial No.	Name	Type locality	No. by type locality	Enter: seiner, trawler, gillnetter, etc.	(Fishing unit code)	Number of fishing units	Total	Registered	fishing unit code 1	fishing unit code 2	Crew size	Total	Registered	fishing unit code 1	fishing unit code 2	Crew size	Landing period	Dominant species	Months of peak, low catches			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18						
				1. Separately for ports 2. Separately for landing places		1 2 3 4															Code: e.g., 1. consumers, 2. retailers, 3. wholesalers, 4. processors		
						1 2 3 4																	
						. . .																	
				Total 1		1 2 3 4																	
				Total 2		1 2 3 4																	

FORM B: AERIAL FRAME SURVEY:
TRADITIONAL AND ARTISANAL FISHERIES
(DIRECT COUNTING)

(a) Stratum ☐☐
(b) Island ☐☐

(c) Flight No.: ☐, (d) Cruising speed (n.mi/hr): ☐☐☐, (e) Altitude (m, or ft): ☐☐☐, (f) Survey period: ☐☐☐☐ - ☐☐☐☐

(h) Date: ☐☐☐☐☐☐

(i) Observers, c.no.: ☐☐

Compact cluster		1. No. of inactive boats seen					2. No. of active fishing boats seen					Remarks	3. Fishing gears seen by type				Remarks
Time unit, ser.no.	Area unit ser.no.	Total	By type (c.no.)				Total	By type					1.	2.	3.	.	
			1	2	3	.		1	2	3	.						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Note: For crusing speed 120 n.mi/hr, time unit of 10' corresponds to area unit of 20 n.mi.

FORM C: INVENTORY OF INDUSTRIAL FISHING
CRAFT CHARACTERISTICS

(a) Stratum ☐☐
(b) Island ☐☐

(c) Enumerator ☐
(d) Date: ☐☐☐☐☐☐

Item/particulars	Data
1. Identification particulars[a/] 1. Name of company or owner: 2. HQ: 3. Type of boat: 4. Name of boat/registration no.:	
2. Economic characteristics 1. Price brand new: 2. Price to owner: Date: 3. Year of construction: 4. Shipyard:	
3. Operational characteristics 1. Material 2. Length over all (m) 3. GRT: 4. Motor type: HP at __ r.p.m. Maker, date: Auxiliaries: Fuel consumption at __ r.p.m. 5. Holding capacity: Ambient (m^3) Ice (m^3) Refrigerated (m^3) 6. Equipment: Refrigeration Freezing Processing 7. Fish finding devices (describe): 8. Crew composition (describe): 9. Gear type (describe): Date acquired: Present condition: Acquired price: Supplier: Origin:	
General remarks:	

a/ One form to be completed for each fishing vessel

FORM D: MASTER LIST OF INDUSTRIAL FISHING VESSELS

Quarterending_____1984____

Fishing agency name	Sr. No.	Vessel name	Type	Crew size	Gross tonnage	Dimension (m)			H.P.	Fish finder	Remarks
						L	B	W			

b. Catch and effort statistics: (logbooks and observer's vessel sheets)

For larger, fishing vessels, log books of the types shown in Forms F and G may be useful for direct estimation of catch and effort by species. One copy should be completed for each trip of short duration. For longer trips a line should be completed daily. These forms are in two copies: an original for the department, and a yellow copy for the fisherman. In some countries such logs are requirements for licensing, but voluntary completion often results in more reliable data, but the confidentiality of the information will need to be repeated. This approach is not well adapted for use on small boats. Here, an interview system is more appropriate.

Ministry of Agriculture and Natural Resources
Fisheries Division, Sierra Leone

Form 3.3

Vessel Log Sheet

Vessel..... Horse power..... Date.....

Gear.....

	Haul 1	Haul 2	Haul 3	Haul 4	Haul 5	Haul 6	Total
Time started							
Time ended							
Duration of tow							
Statistical area fished							
Discards (specify)							
Mackerel/scomber							
Ladyfish/Kapitan							
Crocus/Pristipoma							
Snapper/Zuban							
Tenny/Albulia							
Spanish/Sulema							
Whiting/Kapitan							
Barracudas							
Sole/Yazik							
Sheephead/Babochka							
Shinenose/Sulema							
Butterfish/Otoperka							
Karanx							
Trachurus Spp.							
Catfish/Som							
Grouper							
Record/Merou							
Sardinella							
Others							
Total							

Note: This form is to be filled in triplicate.

FORM F: MARINE FISHERIES PRODUCTION SURVEY
(1) LOGBOOK FOR TRAWLERS

Sample No._____ Province_____ District_____

Name of Reporter_____ Month_____ Year_____

Date of Interview_____ Name of Enumerator_____

Type of fishing method	
Otter board Trawl	(*)
Pair trawl	

Fishing boat	
1. Name of owner	
2. Name of boat	
3. Length of boat	

Date		Number of hauls	Catch by species (kg) (*)															
Dep.	Ari.		Total	Indo-Pacific mackerel	Caranx	Thredfin	Black Pomfret	White Pomfret	Silvery Lactarid	Barracuda	Jewfish	Thredfin bream	Monocle bream	Lizard fish	Hair tail	Snapper	Caranx	Big eye

(*) Modify species/gear as required

FORM F: MARINE FISHERIES PRODUCTION SURVEY:
(1) LOGBOOK FOR TRAWLERS

Fishing efforts			
1. Main fishing area		5. No. of haulings	Haul
2. Landing place		6. Hauling hour	Hour
3. Duration of trip - days		7. Total catch	kg.
4. No. of fishing days	Day	8. Discards	kg.

Catch by species (kg.)																			
Whiting	Catfish	Indian halibat	Sole	Eel	Ray	Shark	Miscellaneous fish	Trash fish	White shrimp	Jambo shrimp	Tiger shrimp	Yellow shrimp	Pink shrimp	Other shrimps	Lobster	Swimming crab	Squid	Cuttlefish	Octopus

FORM G: MARINE FISHERIES PRODUCTION SURVEY
(2) LOG BOOK FOR PURSE SEINER AND OR GILLNETTER

Sample No._____ Province_____ District_____

Name of Reporter_____ Month_____ Year_____

Date of Interview_____ Name of Enumerator_____

Fishing boat		Type of fishing method (/ mark) (*)	Purse seine
1. Name of owner			Chinese purse seine
2. Name of boat			Mackerel encircling gillnet
3. Length of boat			Spanish mackerel gillnet
			Anchovy purse seine

Date		No. of hauls	Catch by species						
Dep.	Ariv.		Total	Indo-Pacific mackerel			Indian mackerel		
				Small	Med.	Large	Small	Med.	Large

(*) Modify gear and species categories as required
Substitute correct local names as appropriate

FORM G (Cont'd)

Fishing efforts			
1. Fishing area		5. No. of hauls	Hauls
2. Landing place		6. Hauling hours/hauls	Hours
3. Duration of trip	Days	7. Total catch	Kg.
4. No. of fishing days	Days	8. Discards	Kg.

Catch by species (*)										
Bonito	Caranx	Torpedo travelly	Russel's scad	Spanish mackerel	Black pomfret	Dorab	Anchovy	Sardine	Acetes	Others

* Substitute correct local names as appropriate

Form

TRIP REPORT OF INDUSTRIAL FISHING VESSELS

Page____of____

Name of Company_____

Name of vessel_____ Trip no._____ in 198

Departure date_____ Port_____

Arrival date _____ Port_____

Gear used:

Trawl ☐ Headline(m)—— Sweepline(m)——

Purse seine ☐ Floatline(m)—— Depth (m) ——

Longline ☐ Length (m) —— No.of hooks——

Gill/driftnet ☐ Length (m) —— Breadth (m) ——

Other (specify) ☐

Date											Trip total
Fishing area											
Target fish											
Vessel speed (knot)/hour											
No.of hauls											
Fishing hr.											
Depth (m)											
Catch by species (kg)											
	Others										
	Discards										
	Total										

Example of the type of form used for recording measurements of many specimens of the same species

Code

Category Vessel

Number of baskets, boxes or parcels Date Fish

of

* All fish measured; non discarded (Delete as appropriate)

* 1 measured: discarded

0													0									
1													1									
2													2									
3													3									
4													4									
5													5									
6													6									
7													7									
8													8									
9													9									
0													0									
1													1									
2													2									
3													3									
4													4									
5													5									
6													6									
7													7									
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1													1									
2													2									
3													3									
4													4									
5													5									
6													6									
7													7									
8													8									
9													9									

FORM L: COST AND EARNINGS SURVEY OF FISHING CRAFT AND GEAR
ESPECIALLY (NON-MECHANIZED) CRAFT

(from Kurien and Willmann, 1982)

a. Identification

District /island	Centre	Code	Name of craft and gear	Sample	Number code

		Dates			
Month	From		To	Total number of days	Total number of trips

Enumerator's name and signature	Date	Supervisor's signature and date	

FORM L (Cont'd)

b. General Information

								Total F	Total U	Average/ trip
	Date									
	Trip									
Prevailing conditions 1	(i) Sea (F or U)									N.A.
	(ii) Wind (F or U)									N.A.
	(iii) Current (F or U)									N.A.
	(iv) Weather on land (F or U)									N.A.
Timing of operation 2	(i) Departure time							N.A.		N.A.
	(ii) Start of fishing							N.A.		N.A.
	(iii) End fishing							N.A.		N.A.
	(iv) Back in port							N.A.		N.A.
	(v) Time spent fishing 2(iii)-2(ii)									
	(vi) Total time 2(iv)-2(i)									

Depth of the sea	Depth at fishing site (in meters)							
Man power and fishing effort 1	(i) Total number of persons involved in fishing operation							
	(ii) Number of non-owners involved in fishing operation							
	(iii) Total fishing effort[a/]							

(a/ Calculated subsequently)
(F - Favourable U - Unfavourable N.A. - Not applicable)

FORM L (Cont'd)

c. Costs

Non-Mechanized Craft

Date		
Trip		
1	Owner's expenses	(i) Bait
		(ii) Hook and line
		(iii) Repairs and maintenance of craft
		(iv) Repairs and maintenance of gear
		(v) Interest on capital invested[a/]
		(vi) Depreciation of craft and gear[a/]
		(vii) Other expenses (describe)
2	Owners loss	(i) Loss of gear
		(ii) Loss of craft
		(iii) Other losses (describe)
3	Common expenditure before sharing the catch	(i) Bait
		(ii) Food
		(iii) Other common expenses for workers/partners
		(iv) Traditional taxes offerings etc.
		(v) Other expenses (describe)

a/ Dot it at the end

FORM L (Cont'd)

d. Marketing

Date				
Trip				
Details of fish marketing * 1	(i) Species	(a) Main species		
		(b) Other species		
	(ii) Measure	(a) Main species	(1) Local unit	
			(2) Standard unit (kg)	
		(b) Other species	(1) Local unit	
			(2) Standard unit (kg)	
	(iii) Mode of selling (B, A, F or O)	(a) Main species		
		(b) Other species		
	(iv) Purchaser (E, S, L, P, M or O)	(a) Main species		
		(b) Other species		
	(v) Final market (Ex. IN or ID)	(a) Main species		
		(b) Other species		

*See page 51, footnote 2

e. Earnings

Date	
Trip	
Earnings from fish sales 1	(i) Price stated
	(ii) Ready cash received
	(iii) Cash received after settlement
	(iv) Time taken for final settlement
Other income from craft & gear 2	(i) Income from rent
	(ii) Income from other sources
Distribution of earnings 3	(i) Total divisible earnings
	(ii) Total number of shares[a/]
	(iii) Value of one share[a/]
	(iv) (a) Proportion of earnings to boat owner[b/]
	(b) To net owner
	(c) To workers
	(d) To others

a/ These items need not be filled if the income is not divided in terms of shares
b/ For mechanized boats and shore seine only

FORM M: COST AND EARNINGS SURVEY
(ESPECIALLY MECHANIZED CRAFT)

Province _____ District _____

Town/village _____ Community _____

House No. _____ Name of owner _____

Strata		Mark
Otter board trawl	Less than 14 m.	
	14-18 m.	
	18 m. and over	
Pair trawl	Less than 18 m.	
	18 m. and over	

1. Fishing Boat Used

Name of boat	Status of possession		Length of boat	Gross tonnage	Type of fishery	Year obtained	Type of boat obtained		Age of boat	Purchase price of new boat	How many years can be used
	owned	hired					new boat	used boat			

2. Main Engine of Boat Used

Name of boat	Name of engine	Horse power	Type of engine	No. of revolution			Year obtained	Type of engine		How many years used	Purchase price of engine	How many years can be used
				Less than 400 rpm.	400 to 1 000 rpm.	1 000 and over		New one	Used one			

1/ Sakurai, T. (1974) Development of Fisheries Statistics in Thailand, Dept. of Fisheries, Ministry of Agriculture and Cooperatives, Bangkok, Thailand

2/ B: Bargaining, A: Auction, F: Fixed price, O: Others (describe), E: Exporter's agent, S: Co-operative Society, P: Poiter, M: Middle men, L: Lorry merchants, O: Others (describe), Ex: Export, IN: Internal neighbouring market, ID: Internal district market

FORM M (Cont'd)

3. NUMBER OF PERSONS ENGAGED IN FISHING

(1) How many crew go fishing?

(1) Total_____(2) Family member(s)_____(3) Employees_____

(2) How many persons in family of owner work on land as permanent worker?

(1) Total_____(2) Family member(s)_____(3) Employees_____

4. WAGE PAYMENT SYSTEM

(1) Type of wage payment system (✓mark is inserted where applicable)

(1) Fixed salary system——— [1) Covered all crew ( )
2) Some crew are excluded ( )]

As the job of crew members for above 2)

_____ _____

_____ _____

(2) Fixed minimum salary plus share ( )

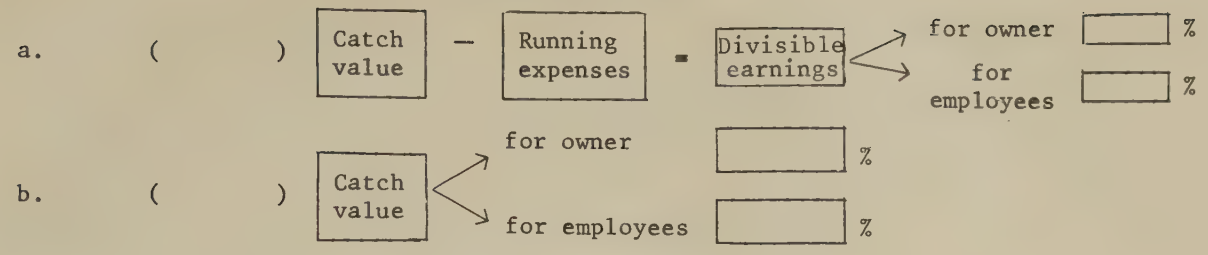
(3) Full share system ( )

Ask details for 4.(1) above, including the amount of salary per month in the case of fixed salary.

Position of crew		Amount of fixed salary per month	No. of crew	Total
Master				
Skipper				
Assistant of skipper				
Engineer				
Assistant of engineer				
Cook				
Chief of fisherman				
Net man				
Crew	1			
	2			
	3			
		Total——→		

Inquire whether or not the owner deducted the running expenses (ice, fuel, food, etc.) before divided the catch value among the owner and employees:

FORM M (Cont'd)



Cost and Earning Survey

(2) For the case a. above:

What kind of running expenses were deducted? (fill all items)

1._____ 2._____ 3._____

4._____ 5._____ 6._____

(3) For cases a and b above:

What percent of catch value or divisible earnings was shared with the employees? (enter the percentage share for employees into a or b above)

(4) Period of payment (✓ mark is inserted wherever applicable)

(1) Salary paid each trip ( )
(2) Salary paid each month ( )
(3) Others ( )

(5) Type of salary (✓ mark is inserted wherever applicable)

(1) Payment only in cash ( )
(2) Cash plus kind ( )

(5) Status of Fishing Operation

Items	Fishing area				
Fishing season. (1) Engaged in fishing (2) Others (repairing docking, etc.)	January February March April May June July August September October November December				
No. of months engaged in fishing					
No. of trips per month					
Average no. of days per trip					

FORM M (Cont'd)

(6) Average Cost and Earning per Trip

(1) Total catch and earnings per trip

		Valuable fish				Trash fish	Total (currency units)
		Fish kept in box	Fish counted by number	Shark and ray	Crab		
Catch	Sold fresh						
	For home processing						
	Total						
Average price per unit							
Total earnings							

(2) Running cost, remuneration and charge for selling

Items			Quantity	Unit price	Total
Running expenditure	Fuel and lubricating oil				
	Ice				
	Food				
	Water				
	Fish boxes or baskets				
	Other materials				
	Total				
Remuneration	Paid in cash	Fixed salary			
		Share			
	Pay in kind				
	Total				
Charge for selling					

FORM M (Cont'd)

(7) Other Costs for One Year

Items	Contents	Amount
Maintenance and repair of boat (1) Vessel hull (2) Main engine (3) Machinery (winch, generator) (4) Fishing and navigation equipment Total		
Repair and renewal of fishing gear (1) Fishing net (2) Rope (3) Others (float, sinker, hook, etc.) Total		
Shore cost (1) Wharfage and dock rental (2) Unloading labour charge Total		
Fishing equipment on land		
Other charge and fee (1) Fee for hired boat (2) Fee for boat registration and fishing gear registration (3) Other Total		
Depreciation cost (1) Boat (2) Engine Total		
Administration expenses		

FORM M: (Summary Table)

Items			Amount estimated
Total catch (1 000 kg)			
Fisheries gross earnings			
Fisheries cost	Remuneration (include food)		
	Running cost	Fuel and lubricating cost Ice Fish boxes or baskets Others Total	
	Boat maintenance		
	Repair and renewal of fishing gear		
	Shore cost	Change for fish selling	
		Others	
	Other charge and fee		
	Depreciation cost		
	Administration expenses		
	Total		
Owners' surplus			

(d) CE-S's of Complex Fishing Units

For complex fishing units (e.g., cooperatives) when boat repair/building, swine boats, and shore facilities concludes one unit and where fish processing is also taken place, a more detailed questionnaire may be needed for obtaining the complete spectrum of characteristics required. (Form N). In general however, a choice should be made between Forms L, M and N in designing the appropriate form.

I. Particulars of Owners

1. Full name:

2. Permanent residence:

Name of house Name of street Island Atoll

3. Is the owner actively engaged in fishing as skipper or crew member?

Yes ☐ No ☐

4. Does the owner keep records on the costs and earnings of his boat?

Yes ☐ No ☐

5. How many fishing boats are in the possession of the owner?
Note: IN CASE THE OWNER OWNS MORE THAN ONE FISHING BOAT PLEASE FILL IN ONE QUESTIONNAIRE FOR EACH BOAT SPARE COPIES OF THE QUESTIONNAIRE ARE AVAILABLE WITH YOUR LOCAL AUTHORITY (SPECIFY NAME, ADDRESS)

FORM N (Cont'd)

II. Details of Boat and Engine

(1) Type of boat: unmechanized: sail ☐
oar ☐
mechanized: inboard ☐
outboard ☐
Horsepower (specify)_____
Construction: wood ☐
fibreglass ☐
other (specify) ☐

(2) Size of boat (specify length and/or tonnage):_____
Registration number:_____

6. Crewing

In addition to masterfisherman/skipper, how many crew regularly from?

What are the arrangements for payment of crew/or crew shares? Specify.

7. Design of boat:

8. Average number of crew members on board the vessel:

9. How did you acquire the boat? inheritance ☐ built ☐

Purchase of new boat ☐ Purchase of second-hand boat ☐

10. When did you acquire the boat? Month: Year:

11. In the case of second-hand boats, how old was the boat at the time of purchase: (years)

12. For owners of mechanized boat: was the boat mechanized at the time of acquisition?

Yes ☐ No ☐

13. How much did the boat cost? If purchased:

If built:

Cost of wood:

Cost of carpenters:

Other costs:
(excluding engine, sails, oars, nets, anchors, poles, lines, hocks).

14. What were the sources of financing the boat?

Own savings ☐ Credit from banks ☐

Credits from others (neighbours, relatives, etc.) ☐

15. What is the expected future lifespan of the boat when you regularly clean and oil it? (years)

16. If the boat has been mechanized, when was the engine installed?

Month: Year:

FORM N (Cont'd)

17. What were the costs of mechanization?

Installation costs: Engine cost:

18. Type of engine: Horse power:

19. Are boat and engine insured? Yes ☐ No ☐

If yes, how much is the insurance cost per year?

20. Did you receive Ministry's credit for mechanization?

Yes ☐ No ☐

21. In case you have received Ministry's credit, what repayment option have you chosen?
Years:

22. Are you still repaying this credit? Yes ☐ No ☐

If yes, what is your present bi-monthly rate of repayment?

23. Please give the costs and the average lifespan of the following equipment on your boat:

Numbers	Cost of one	Average lifespan
Sails		
Anchors		
Oars		
Bait net		
Shark net		
Water carrier		

24. Please specify, who owns the above equipment?

Boatowner ☐, Skipper ☐, Crew ☐, Others ☐

25. Does the equipment owner(s) receive an extra share of the earnings? Yes ☐ No ☐

III. Repairs and Maintenance

1. During the last 12 months have there been any repairs or replacement of the following items:

1. poles 2. lines
3. hooks 4. bailers

If yes, please specify and give costs:

2. Did you have repairs of boat or engine during the last 12 months?

Yes ☐ No ☐

If yes, repair costs for engine:

repair costs for boat :

FORM N (Cont'd)

3. How often is the boat beached per year?
   for cleaning only:
   for cleaning and oiling:

4. What are the average costs of
   cleaning only:
   cleaning and oiling:

5. For how many days is the boat beached:
   when cleaned:
   when cleaned and oiled:

Breakdown of Vessel Expenses

(a) On a per trip basis (the last trip)

Expenses for a trip of_____days duration beginning (date)

Observer_____vessel name_____

Date_____skipper/interviewers_____

Location_____type/size/vessel_____

(b) Expenses during last trip

Trip duration_____(days) beginning_____(date)

Items:

(1) Fuel used per trip_____(gallons/litres) at_____(cost) per unit

(2) Lubricant per trip_____(" / ") at_____ " " "

(3) Wages/shares per trip:

(a) Deckhands (No._____wages_____)
(b) Engineer (No._____ " _____)
(c) Captain (No._____ " _____)
(d) Cook (No._____ " _____)
(e) Other (specify)(No._____ " _____)
(f) Vessel share if any (_____)

(4) Other payments received by Captain/crew by commissions/bonuses)
Specify:

(c) Breakdown of vessel expenses on a trip basis

(Expenses for a trip of [ ] days duration beginning [ ] (date)

Items:

(1) (a) Fuel used per trip (gallons, litres) at [ ] (cost) per unit

(b) Lubricant " " " " at [ ] " " "

(2) Food costs per trip [ ] for a crew of [ ] (No.)

(3) Wages/share per trip (a) deckboard [ ] (b) captain [ ]

(c) engineer [ ] (d) other (specify) [ ] (e) vessel

share [ ] (f) owner share [ ]

FORM N (Cont'd)

(4) Other payments made to captain and crew (by commissions, bonuses, or specify)

[ ]

(5) Harbour/wharfing charges per trip [ ]

(6) In kind payments to crew (fish): [ ] kilos at [ ] landed unit price.

(7) (a) Vessel/engine repair costs over last trip [ ]

(b) " " " " " " calendar year [ ]

(8) Damage/replacement of fishing gear, cables, deck machinery and other fishing equipment

specify [ ]

(9) Electronic repairs and replacement [ ]

(10) Amounts of unit price of ice [ ] [ ] salt [ ] [ ]

packaging [ ] [ ] other (specify) [ ] [ ]

(11) Landing taxes or charges [ ]

(12) Charges for handling/unloading [ ]

(13) Other costs (specify) of transport [ ]

[ ]

(14) When was the vessel last (_____date)

Cost: machinery [ ] any dock or ship way

[ ] labour cost [ ] /storage [ ]

(15) Resale: any money from resale of replaced equipment [ ]

(b) Vessel expenses on an annual basis

Rental of equipment [ ]

Vessel insurance [ ]

Crew accident insurance [ ]

License fees (by radio) [ ]

Repayment on loans [ ] on_____(specify item)

at_____% simple compound interest

Amount outstanding on loan [ ]

Date of vessel purchase_____(new/used)

Other (specify)_____

(c) Crew expenses

Pension [ ]

Insurance [ ]

Other (specify) [ ]

FORM N (Cont'd)

(v) Landings and Discards

(1) Landed value per trip

Landed weight and value of species/category A, B, C, (etc.) by vessel_____

(name) at port_____on trip_____from_____(date) to

_____(date): weight of 1 unit of catch = _____kilos

Species or category	Bushels/boxes /other unit (specify:_____)	Landed price/unit
A	_____	_____
B	_____	_____
C	_____	_____

(2) Discards

Estimated discards per ton of species A, B, C.....Z. (_____tons per day for a trip of_____days fishing).

Species A_____bushels/boxes/other (specify)
B_____ " " "
C_____ " " "

(3) Catch spoilage

_____kilos of category/species_____landed with unit value of _____kilo.

(vi) Processing, Marketing and Export Sections

For shore plant, (optionally including company-owned vessels also), it is usual to divide costs of production into fixed and variable costs. In evaluating revenues and costs, and performance of an enterprise, the following types of information are useful:

(1) Revenues

Species/category	Plant	Administration	Total
(a) Sales I. Fish species/Category I Export sales: Domestic sales: II. Fish species/Category II Export sales: Domestic sales: III. Fish species/Category III Export sales: Domestic sales: Etc.			
(b) Processing fees: (c) Berthing/slipway/storage fees (d) Rental buildings/equipment /vehicles (e) Handling charges (f) Sales equipment/fishing gear (g) Other(specify)			

FORM N (Cont'd)

(2) Variable costs	Plant	Administration	Total
(a) Wages/salary/other employee costs			
(b) Fuel/lubricants			
(c) Rental (land/buildings/ equipment)			
(d) Workshop/repairs			
(e) Packaging material/other supplies			
(f) Chemicals/additives			
(g) Spoilage losses			
(h) Laboratory tests			
(i) Discounts on sales			
(3) Fixed costs			
(a) Salaries/wages/other employee costs			
(b) Pensions			
(c) Training/travel			
(d) Office/laboratory plant and equipment			
(e) Telex/cables/telephone			
(f) Fuel			
(g) Water/sewage			
(h) Maintenance			
(i) Pest control/safety			
(j) Rentals			
(k) Insurance			
(l) Depreciation			
(m) Interest/service charges			
(n) Taxes and rates			
(o) Legal/auditing fees			
(p) Service charges/donations subscription			
(q) Sales promotion/advertising			

(f) Breakdown of Operating Time During Fishing

Estimating the time spent in the various phases of the fishing operation can be important in defining the true fishing effort, and in evaluating the costs and benefits of present and alternate fishing strategies. A questionnaire of the following general form could be completed by interview of a representative sample of fishermen skippers.

FORM O: TIME AND MOTION STUDY OF FISHING OPERATION

(1) Travel time

Home post: Date:_____ Skipper_____ Type_____

Port of landing: Observer:_____ Boat name_____ fishing_____

Location:_____ Type/size_____

Name of fishing ground	Distance from home port	Steaming time (hrs)	Distance from port of landing	Steaming time(hrs)	No. trips in last year

(2) Total duration, last trip (specify hrs/days):_____

(3) Fishing ground visited _____

(4) Time spent actually fishing (" " ") _____

Breakdown of Fishing Time

(a) Time searching
(b) Setting/hauling gear
(c) Time gear is actively fishing
(d) Other (specify)

(5) Time spent in port between last two trips_____(days)

(a) Unloading _____ (days)
(b) Maintenance _____ (days)
(c) Purchase/loading ice and supplies _____ (days) Average turn-around time _____ (days)
(d) Awaiting improved weather/tide conditions _____ (days)
(e) Other (specify) _____ (days)

(6) Time that boat was not fishing since the time last year:

_____(weeks/month) Reason:_____

(7) Number of trips made since this time last year:_____

(8) Number of trips made in last year to fish for principal species A_____

B_____

C_____

Etc.

(g) Household Surveys and Fish Consumption

Localized fish consumption surveys can be used for obtaining information on the inventory characteristics of the population size fishing in the area, and on fish consumption data. In these kind of surveys the survey subject is the "household"[1/]. It should be noted that households in developing countries are both production and consumption units.

The survey system used for data collection is stratified by sampling areas. Information from the sample households (hhs) is obtained by using the interview approach.

The sampling frame used for the selection of the sample in the survey can be either the data of a population census programme or of an agricultural census programme. For small areas, the census method might be used for data collection.

It should be noted that the results obtained from the surveys, as far as inventory characteristics of the fishing industry is concerned, must be double checked for consistency before being released. Usually, external data are available for "validation" purposes.

Data or purchase of fish are subject to various kinds of "memory errors" and a tendency to misreport on the part of the respondent. The results obtained should be treated as indications rather than as estimates of the magnitudes in question.

Form P provides an example of the format of the questionnaire that could be used for this kind of survey.

FORM P: INVENTORY OF FISHING HOUSEHOLDS AND FISH CONSUMPTION

(One form to be completed for each household interviewed)

Island _____ Municipality _____

Date _____ Address (if available) _____

_____

Name of head of household _____

Number of persons in household _____ Number of persons who fish for pleasure, food, or full/part time employment _____

Number of persons who fish in municipal fishery:

Full time _____

Part time _____

Sports fish _____

Total number in municipal fishery _____

Usual place of landing _____

Does your family own a boat?

☐ yes ☐ no

If yes, how many? _____

What kind? _____

1/ The definition adopted by the UN for the Census Programme is as follows: the concept of "household, hh" is based on the arrangements made by persons individually or in groups, for providing themselves with food and other essentials of living. One hh may be either a one-person hh, or a multi-person hh. Hhs usually occupy the whole, part of, or more than one housing unit, but they may also be found living in camps, in boarding houses or hotels, or as administrative personnel in institutions.

Number of persons engaged in fishery activities other than fishing, such as:

(check off)

Processing _____ unmotorized < _____ 15 ft

Transporting _____ unmotorized > _____ 15 ft

Selling _____ motorized > _____ 15 ft

Other (specify) _____ motorized < _____ 15 ft

Total number _____

Purchase of fish:

Does your family eat fish? ☐ yes ☐ no

How many meals of fish did you eat in the last week (7 days)?

What kinds of fish did you eat and how much (lb)?

Crawfish _____ Grouper _____ Grunts _____

Conch _____ Snapper _____ _____

Turtle _____ Jacks _____ Other _____

Did you or your family catch it yourself? _____

Trade it for other commodities? _____

Receive as a gift? _____

Buy direct from the fisherman? _____

Buy at a store? _____

Locally produced? _____

Off island produced? _____

(h) Statistical Surveys of Sport Fisheries

Sport fisheries have a wide range of coverage of several different types, e.g., organized sport fish tournaments, shore based sport fishing, underwater scuba fishing. It is clear that the less sophisticated types of sport fishing is more likely to overlap with subsistence fisheries, however the advantage of surveys of sports fisheries, especially tournaments is the general enthusiasm and interest of the fisherman, and the real possibility of obtaining detailed data on catch rate, species and sizes.

Surveys of shorebased sport fishing (other than tournaments), can be integrated partially with the main Frame Surveys and catch assessment surveys. An inventory of the number, size and type of vessels/gear used, number of fish tournaments, sponsoring organizations, species in incidental catch etc., is required for assessing the importance of organized sport fishing activities. From the perspective of the economic contribution of sports fishing to the local economy, other statistics would probably be collected by the department of tourism (e.g., on length of stay, expenditures on travel, hotel, food, excursions, etc.).

The following draft form (Q), confines itself to collecting information on the primary sports fishing operation, and can be used either for tournaments, or for individual excursions (filled out by fishermen or charter skippers).

FORM Q: SPORTS FISHING CATCH SURVEY

Tournament ☐ (yes/no)

No boats fishing in tournament ☐

Name respondent:

Skipper/owner (a), sportsman (b), both (c) ☐ (enter a, b or c).

Port/landing point: island:

Date:

Boat type: Propulsion (rick box)

Length: (m) sail ☐

oars ☐

inboard ☐

outboard ☐

from shore ☐

Charter cost _____ ? per hour ☐ per day ☐ ?

(specify currency) _____

Fished in area/tournament before? ☐

often ? ☐

How many years have you been sports fishing in the islands? _____ (years)

Main target species in order of priority: a. _____

b. _____

c. _____

Name and location of fishing areas today: a. _____

b. _____

Hours at sea: _____

Hours actually fishing: _____

Weather conditions (sea) _____

(wind) _____

(sky cover) _____

Depth _____ (m)

Number lines fished _____ depth fished _____ (m)

Stationary? ☐ trolled? ☐

Total No. strikes? _____

No. sightings fish? (species: _____)

(species: _____)

No. fish landed	Species	Size/weight (specify units)
a. _____	_____	_____
b. _____	_____	_____
c. _____	_____	_____
d. _____	_____	_____

Remarks

APPENDIX 3

The Accredited Fish Dealer and the Sales Purchase Slip as Mechanisms for Controlling Sales and Export of Lobsters, and Other Species in Danger of Overexploitation, and for Collecting Basic Information on Landings

Especially for the lobster resource, in the Antilles there is a major component of direct sales from fishermen to foreign buyers who are exporting lobsters directly to adjacent countries or to private consumers, hotels, etc. This in itself is not a bad thing, but the sources of greatest concern are that:

(a) This makes it difficult to accumulate good statistics on this market, or the landings;

(b) the unrestricted sales and rising prices that will result from a high, unsatisfied demand as the lobster fishery becomes overfished, will cause yet higher levels of fishing, and may soon, or already has, seriously damaged the resource.

One approach to monitoring and controlling this process is by means of registration of both fishermen and dealers who are authorized to sell lobster, and by a ban on the sale of lobsters (and preferably also on their capture) by individuals who are not registered in this way. A supplementary regulation allowing export only by those individuals having an export licence is feasible, but would tend to encourage smuggling, and penalize fishermen in favour of a few licensed individuals, given the relatively unorganized marketing system. Although there is no intention here to prevent authorized fishermen from selling directly to customers, it is suggested that the onus be placed on the purchaser to obtain a sales slip from the dealer or fisherman on purchasing lobsters. A book of sales slips could be issued to each accredited fisherman or dealer, with three copies: one to be retained by the purchaser (and shown if leaving the country with lobsters), one kept by the fisherman/dealer, and one to be collected by government extension workers, as a basis for statistical monitoring of the fishery. Initially, it might be wise to just introduce this system for export sales, and then only after an appropriate period of advertisement should exporters not having purchase slips be penalized. Full consultation with fishermen as to the purpose of this system will be necessary.

A typical sales/purchase slip is shown in Figure 4; here the design of the slip allows it to be used for controlling:

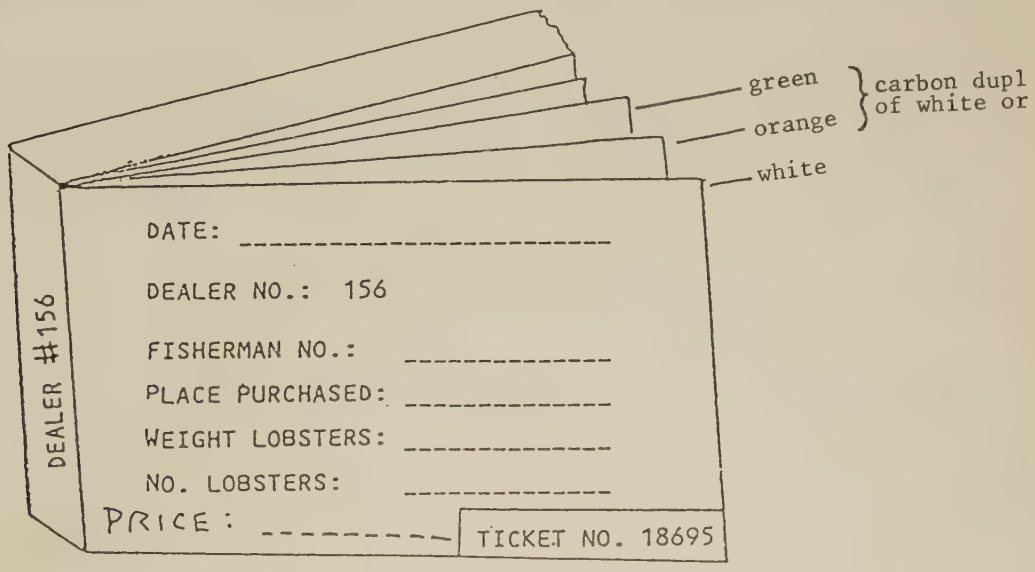


Figure 4 One possible design of a book of purchase/sales slips for issue to accredited dealers/fishermen

(a) purchases from fishermen by dealers, in which case the licence number of the fisherman selling the lobster is recorded; or

(b) sales to the public by either dealers or fishermen, in which case the pre-printed number of the dealer (who may be a fisherman) and the ticket number identify the individual sale, and the space for "Fisherman No." is left blank.

Some regulations that will help ensure that reliable catch data are recorded are:

(1) Dealers who are not also fishermen in possession of lobsters without corresponding sales/purchase slips will be infringing the regulations, unless evidence of importation is shown.

(2) Any exporter of lobsters must show a valid sales slip, unless evidence of importation is shown.

(3) Any retail business or hotel in possession of more than 10 kg. of lobsters must show corresponding purchase slips, unless they can show that the lobsters were imported.

Obviously, discussion of the possible ramifications of this scheme within the appropriate department of fisheries, and with local authorities, is necessary preceding implementation. For some fishermen a literacy problem may exist that requires the sales slip to be as simple as possible. There may be a problem in showing price of purchase or sale on the slip in convincing fishermen that this data is not being collected for fiscal purposes. The possible impact of this will need to be carefully considered on the viability of the scheme.

It should be stressed that this scheme is not designed to impede direct sales by fishermen, although a system of dealers, at least for sales to non-nationals, will ensure that a fair price is obtained for the product, that in part reflects the final sales price to consumers in the importing countries.

NB: If considered appropriate, this approach could be extended to other uses, e.g., conch, turtle or even reef fish, but it is suggested that a trial period in a limited area should be considered before widespread adoption, to pick up possible problems.

APPENDIX 4

Basic Sampling Theory and Sampling Design

CONTENTS

1. Population, frame, sampling units, survey units

2. Method of selection

   2.1 Simple random sample (SRS)

3. Estimation of population mean from a sample and precision of estimate

   3.1 Estimation of population total and precision
   3.2 Sample size

4. Estimation of proportions and their uses

5. Stratified sampling

   5.1 Sample size in different strata

6. Ratio estimation

7. Unequal probability sampling

   7.1 Method of selection
   7.2 Method of estimation

8. Two stage sampling

   8.1 Selection of first stage units at random
   8.2 Selection of first-stage units with probability proportional size (pps)

1. Population, Sampling Frame, Sampling Units, Survey Units

Whenever a survey is contemplated, it is first necessary to specify the units which require to be included in the survey, and their geographical context. All rigorous sampling demands a subdivision of the material to be sampled into units, termed "sampling units", which form the basis of the actual sampling process. Clear and unambiguous definition demands the existence or construction of a list (= sampling frame) of the sampling units. In the case of a Catch Assessment Survey (traditional and artisanal fisheries) the following hierarchy of sampling units can be introduced:

- Primary sampling units (PSU's): landing places
- Secondary sampling units (SSU's): fishing economic units

Items of information on the survey characteristics are collected from the above SSU's, which, are also called "survey units".

For data collection one of the following two survey methods can be used:
(a) The census method. This implies complete enumeration of the survey population; in a census method information is obtained from all the survey units in the population, and (b) The sampling method, where information is obtained from a properly selected fraction of units of the survey population. In large-scale surveys, the sample selection is from the existing sampling frame.

2. Selection of Sample Units

If there are N sampling units in the population and we want to draw a simple random sample[1/] of size n, we can work out all possible samples of size n and select one of them at random. The number of all possible distinct samples of size n which can be selected from a population N is given by:

$$\binom{N}{n} = \frac{N!}{n!(N-n)!}$$

where, ! stands for factorial e.g., 3! = 1x2x3, etc. For example, if N = 4 and n = 2, the number of distinct samples which can be selected is given by:

$$\frac{4!}{2!2!} = \frac{1x2x3x4}{(1x2)(1x2)} = 6$$

In practice, when N is large, it is not possible to enumerate all possible distinct samples and then select one of them. Normally, a simple random sample is drawn unit by unit. The units in the population are marked serially from 1 to N. We then refer to a table of random numbers (see Appendix Table 1) and draw from this table a series of n numbers lying between 1 and N, taking care to reject numbers above N and not allowing the same numbers to appear in the series more than once. The units in the population marked as per the number selected in the series constitute our sample of n selected units. It has been proved that this method produces simple random samples.

Example

There are N=28 landing sites in a district. We want a simple random sample of n=5 landing sites.

Since N=28 is a two-digit number, we refer to any row of two-digit numbers in the Random Number Table. Referring to the first row of two-digit numbers, we find the consecutive numbers are: 23, 5, 14, 38, 97, 11, 43, 93, 49, 36, 7, etc.

Now select those that lie between 1 and 28, until we have selected a series of 5 numbers. The selected series is: 23, 5, 14, 11 and 7.

1/ This means, every unit in the population has an equal and no zero probability of being selected in the sample

The landing sites marked with these numbers in the population constitute our sample.

3. Estimation of Population Mean from a Sample and Precision of Estimate

If there are N units in the population and we measure a desired characteristic (y) of all units in the population, then we have:

Population total : $Y = \sum_{1}^{N} y_i = y_1 + y_2 + y_3 + \ldots + y_N$

Population mean : $\bar{Y} = \frac{Y}{N} = (Y_1 + Y_2 + Y_3 + \ldots + Y_N)/N$

The variability in the measured characteristics among the population units is given by S_y^2

$$S_y^2 = \frac{1}{N-1}\left[\sum_{1}^{N} y_i^2 - \frac{(\sum_{1}^{N} y_i)^2}{N}\right]$$

Now, if we draw a sample of n units from the N units in the population, we can define:

Sample total : $y = \sum_{1}^{n} y_i = y_1 + y_2 + \ldots + y_n$

Sample mean : $\bar{y} = \frac{y}{n} = \frac{1}{n}(y_1 + y_2 + \ldots + y_n)$

and the variance per unit in the sample is given by:

$$s_y^2 = \frac{1}{n-1}\left[\sum_{1}^{n} y_i^2 - \frac{(\sum_{1}^{n} y_i)^2}{n}\right]$$

If the same method of measurement of the desired characteristics is employed both for the population units and the sample units, the absolute value of the precision of the sample mean is given by:

$$|d| = |\bar{y} - \bar{Y}|$$

Generally, the population mean $\bar{Y}$ is not known and the main purpose of sampling is to get an estimate of $\bar{Y}$ from the sample and also to have a measure of precision of that estimate. Now we know that in SRS we can produce N_{C_n} samples (of n units) from a population of N units, and we can have a series of N_{C_n} sample means $\bar{y}$'s. $E(\bar{y})$ is equal to $\bar{Y}$ and thus $\bar{y}$ is an unbiased estimate of $\bar{Y}$. It has also been proved that in the case of SRS selection, the variance of $\bar{y}$ is given by:

$$V(\bar{y}) = (1 - \frac{n}{N})\frac{S_y^2}{n}$$

or, $= S_{y/n}^2$ if n/N is negligible.

The standard error of the sample mean $\bar{y}$ is given by:

$$S_{\bar{y}} = +\sqrt{V(\bar{y})} = \sqrt{(1 - \frac{n}{N})}\,\frac{S_y}{\sqrt{n}}$$

or, $= \frac{S_y}{\sqrt{n}}$, when $\frac{n}{N}$ is negligible.

$S_{\bar{y}}$ measures the degree of scatter of possible sample means around $\bar{Y}$. The smaller it is, the probability of a large deviation of $\bar{y}$ from $\bar{Y}$ will be small. For $n > 30$, it has been shown that at 95% probability level, the population mean $\bar{Y}$ will lie in the interval,

$$\bar{y} - 1.96\, S_{\bar{y}} < \bar{Y} < \bar{y} + 1.96 S_{\bar{y}}$$

Thus we see that $S_{\bar{y}}$ provides a measure of precision of the sample estimate.

We generally do not know S_y in order to calculate $S_{\bar{y}}$. In SRS, an unbiased estimate of S_y is provided by s_y.

Thus an unbiased estimate of the standard error of the sample mean $\bar{y}$ is given by:

$$s^2_{\bar{y}} = v(\bar{y}) = (1 - \frac{n}{N}) \frac{s^2_y}{n} \text{ , and } s_{\bar{y}} = + \sqrt{s^2_{\bar{y}}}$$

The relative precision of $\bar{y}$ is given by:

$$CV(y) = \frac{S_{\bar{y}}}{\bar{y}}$$

and an unbiased estimate of $CV(\bar{y})$ is given by:

$$cv(\bar{y}) = \frac{s_{\bar{y}}}{\bar{y}}$$

3.1 Estimation of Population Total and Precision

In SRS sample, the estimate of population total is given by

$$\hat{Y} = N \bar{y}$$

and the estimated variance of $\hat{Y}$ is

$$v(\hat{Y}) = N^2 \, v(\bar{y})$$

and the estimated standard error of $\hat{Y}$ is

$$s_{\hat{Y}} = \sqrt{v(\hat{Y})} \ .$$

The estimated coefficient variation of $\hat{Y}$ is

$$cv(\hat{Y}) = \frac{s_{\hat{Y}}}{\hat{Y}}$$

Example 3.1a

In a landing site, 30 boats land their catch on a particular day, and the catches (y_i) of 10 boats selected at random are examined. Estimate the total catch of the day and its standard error and coefficient of variation: N = 30; n = 10.

Sample boat	Catch (kg)	
	y_i	y_i^2
1	12	144
2	8	64
3	4	16
4	6	36
5	0	0
6	16	256
7	5	25
8	9	81
9	11	121
10	9	81

We have: $\Sigma y_i = 80$; $\Sigma y_i^2 = 824$.

The various estimates are:

(a) $\bar{y} = \frac{\Sigma y_i}{n} = \frac{80}{10} = 8$ kg ; $\hat{Y} = N\bar{y} = 30 \times 8 = 240$ kg

(b) $s_y^2 = \frac{1}{n-1}\left[\sum_i y_i^2 - \frac{(\Sigma_i y_i)^2}{n}\right] = \frac{1}{9}\left[824 - 640\right] = 20.44$

(c) $v(\hat{Y}) = N^2\, v(\bar{y}) = N^2 . \left(1 - \frac{n}{N}\right) \frac{s_y^2}{n} = 30^2 \times 1.3626$

(d) $s_{\hat{Y}} = \sqrt{v(\hat{Y})} = 30 \times \sqrt{1.3626} = 35.1$

(e) $cv(\hat{Y}) = \frac{s_{\hat{Y}}}{\hat{Y}} = \frac{35.1}{240} = 14.6\%$

3.2 Sample Size

In Section 3 we have seen:

$$cv(\bar{y}) = \frac{s_{\bar{y}}}{\bar{\bar{y}}} = \frac{s_y}{\bar{\bar{y}}}\sqrt{\frac{N-n}{Nn}}$$

Therefore,

$$\frac{cv(\bar{y})}{cv(y)} = \sqrt{\frac{N-n}{Nn}} = \sqrt{\left(\frac{1}{n} - \frac{1}{N}\right)}$$

If, $\frac{cv(\bar{y})}{cv(y)} = \frac{1}{g}$

then, $\frac{1}{g} = \sqrt{\frac{1}{n} - \frac{1}{N}}$ and $n = \frac{Ng^2}{N+g^2}$

When N is large,

$$\frac{cv(\bar{y})}{cv(y)} = \frac{1}{\sqrt{n}}$$

or, $n = \left[\frac{cv(y)}{cv(\bar{y})}\right]^2$

Now, for large N, at 95% probability level, the population mean will lie within the interval $\bar{y} \pm 1.96\, s_{\bar{y}}$ or roughly within $\bar{y} \pm 2\, s_{\bar{y}}$. Therefore, $a = \frac{2 s_{\bar{y}}}{\bar{y}} \times 100 = 200\, cv(\bar{y})$ represents percentage accuracy of the mean at 5% significance level.

Thus, the sample size n required for an a% accuracy of the mean at 5% significance level is given by:

$$n = \frac{[cv(y)]^2}{(a/2)^2} = \left[\frac{200 \times s_y}{a\bar{y}}\right]^2$$

Example 3.2a

In a survey sample n = 18 gave a mean of $\bar{y} = 589.44$ kg and $s_y = 531.79$. How many units would be needed if it were desired to estimate at a 5% significance level, the estimated mean (a) within 10%, (b) within 5%, and (c) within 1% of the population mean.

We have, $cv(y) = \frac{531.79}{589.44} \times 100 = 90.22$.

Therefore,

(a) Number of units required for getting $\bar{y}$ with an accuracy of 10% is,

$$n = \left[\frac{200 \times 531.79}{10 \times 589.44}\right]^2 = 326 \text{ units}$$

(b) For an accuracy of 5%,

$$n = \left[\frac{200 \times 531.79}{5 \times 589.44}\right] = 1\,302 \text{ units}$$

(c) For an accuracy of 1%,

$$n = \left[\frac{200 \times 531.79}{1 \times 589.44}\right] = 32\,558 \text{ units}$$

Example 3.2b

In Example 3.1a, if we had derived an estimate of $\bar{y}$ with a cv of 5%, what size of sample would be needed.

We have, $cv(y) = \frac{\sqrt{20.44}}{8} \times 100 = 56.50$ percent

$N = 30$

$cv(\bar{y}) = 5.00$ percent

Therefore,

$$g = \frac{56.5}{5.0} = 11.3$$

and, $$n = \frac{Ng^2}{N + g^2} = \frac{30 \times (11.3)^2}{30 + (11.3)^2} = \frac{30 \times 127.69}{30 + 127.69} = 24.29; \text{ i.e., } 24 \text{ boats}$$

4. ESTIMATION OF PROPORTIONS AND THEIR USES

Let there be N units in the population of which N_i belongs to i-class, so that the proportion belonging to class i is: $P_i = \frac{N_i}{N}$. We want to estimate N_i and P_i from a simple random of n units, in which n_i is in class i so that $p_i = \frac{n_i}{n}$.

It has been shown that an unbiased estimate $\hat{P}_i$ of P_i is given by p_i, so that $\hat{P}_i = p_i = \frac{n_i}{n}$, and an unbiased estimate of N_i (where N_i is the number in the class i in the population) is given by: $\hat{N}_i = N \cdot p_i$.

An unbiased estimate of variance of p_i is given by:

$$v(p_i) = \frac{N-n}{n} \frac{p_i q_i}{n-1}, \text{ where } q_i = 1 - p_i . \qquad (4.1)$$

When $\frac{n}{N}$ is small, i.e., n is small compared to N, or N is very large,

$$v(p_i) = \frac{p_i q_i}{n-1}, \text{ or simply } v(p_i) = \frac{p_i q_i}{n} \text{ if n is fairly large.} \qquad (4.2)$$

An unbiased estimate of the variance of $\hat{N}_i$ is given by:

$$v(\hat{N}_i) = v(Np_i) = N^2 v(p_i) . \qquad (4.3)$$

If the magnitude of N is itself an estimate, the estimated variance of N_i is given by:

$$v(\hat{N}_i) = \hat{N}^2 v(p_i) + p_i^2 \text{ var } (\hat{N}) . \qquad (4.4)$$

Example 4.1

A random sample of 82 boats were taken out of 820 boats. It was found that 32 were using lines. Estimate the proportion and number of boats using lines.

Hence, $N = 820;\ n = 82;\ n_i = 32$

$\therefore$ $p_i = \frac{32}{82} = .39$ and $v(p_i) = \frac{p_i\, q_i}{n-1} = \frac{.39 \times .61}{82-1} = 0.0029$

and, $\hat{N}_i = 820 \times .39 = 320$

$v(\hat{N}_i) = 820^2\, v(p_i) = 820^2 \times 0.0029 = 1949.96$

$\therefore$ $\sqrt{v(\hat{N}_i)} = 44.15$

Example 4.2

The number of cods landed was 2 000. A sample of 100 cods were taken and their ages determined, and the distribution is as follows:

Age	8	9	10	11	12	Total
Number (n_i)	14	54	7	19	6	100

Find out the estimated number of cods in each age group in the total landings and the variance of these estimates.

Here we have: $N = 2\ 000;\ n = n_1 + n_2 + n_3 + n_4 + n_5 = 100$

Age	8	9	10	11	12	Total	
n_i	14	54	7	19	6	100	
p_i	·14	·54	·07	·19	·06		
q_i	·86	·46	·93	·81	·94		
$p_i\, q_i$	·12	·25	·07	·15	·06		
$v(p_i) = \frac{p_i\, q_i}{n}$	.0012	.0025	.0007	.0015	.0006		(equation 4.2 for large n)
$\hat{N}_i = N\, p_i$	280	1 080	140	380	120		
$v(\hat{N}_i) = N^2 v(p_i)$	4 800	10 000	2 800	6 000	2 400		
$s(\hat{N}_i) = \sqrt{v(\hat{N}_i)}$	69.3	100.0	52.9	77.4	49.0		

5. STRATIFIED SAMPLING

It has been seen that in simple random sampling the variance of mean $v(\bar{y})$ depends, apart from the sample size n, on the variability of the characteristics in the population, i.e., on S_y^2. If the population is heterogeneous, i.e., measurements vary considerably from one unit to another, then by using auxiliary information, it may be possible to divide it into sub-populations (or strata), each of which is internally homogeneous.

Let us suppose that there are N units in the population and these are stratified into k strata with N_i units in the i^{th} stratum. Let a sample of n units be drawn, of which n_i are from the i^{th} stratum. Let y_{ij} be the measurement of the j^{th} unit in the i^{th} stratum.

Then we have the following:

$\bar{y}_i$ = sample mean of the i^{th} stratum $= \frac{1}{n_i} \sum_{j}^{n_i} y_{ij}$

$\hat{Y}_i$ = estimate of total of the i^{th} stratum = $N_i \bar{y}_i$

and, $\hat{Y}_{st}$ = estimate of population total (5.1)

= sum of strata total estimates

$$= \sum_i^k N_i \bar{y}_i$$

We also have,

$$\bar{y}_{st} = \text{estimated population mean} = \frac{\hat{Y}_{st}}{N} = \frac{1}{N} \sum_1^k N_i \bar{y}_i \quad (5.2)$$

The unbiased estimates of variances are:

$$v(\hat{Y}_{st}) = \sum_i N_i^2 \, v(\bar{y}_i) = \sum_i N_i^2 \left(\frac{1}{n_i} - \frac{1}{N_i}\right) s_i^2 \quad (5.3)$$

where, $$s_i^2 = \frac{1}{n_i - 1} \left[\sum_j^{n_i} y_{ij}^2 - \frac{(\sum_j y_{ij})^2}{n_i}\right]$$

and, $$v(\bar{y}_{st}) = \frac{1}{N^2} \left[\sum_i N_i^2 \left(\frac{1}{n_i} - \frac{1}{N_i}\right) s_i^2\right] \quad (5.4)$$

If the sampling fraction $\frac{n_i}{N_i}$ is negligible for all strata, then we have:

$$v(\hat{Y}_{st}) = \sum N_i^2 \frac{s_i^2}{n_i} \quad (5.5)$$

and, $$v(\bar{y}_{st}) = \frac{1}{N^2} \sum N_i^2 \frac{s_i^2}{n_i} = \sum w_i^2 \frac{s_i^2}{n_i} \quad (5.6)$$

where, $$w_i = \frac{N_i}{N}$$

Example 5

Out of 200 boats in a district, 70 were engaged in line fishing, 120 in gillnet fishing, and 10 in beach-seine fishing. For the purpose of estimating catch, 5 line fishing boats, 7 gillnet boats, and 3 beach-seine boats were selected, and their catches in tons for the month of January were noted as follows:

Line boats	: 2, 3, 4, 5, 6
Gillnet boats	: 7, 8, 9, 10, 12, 13, 11
Beach-seine boats	: 20, 23, 26

What was the estimated total catch in the district in January and the variance of the estimates? What is the mean catch per boat and its variance?

Strata	N_i	n_i	$\bar{y}_i$	s_i^2	$N_i \bar{y}_i$	$N_i^2 (\frac{1}{n_i} - \frac{1}{N_i})$	$N_i^2 (\frac{1}{n_i} - \frac{1}{N_i}) s_i^2$
1	70	5	4	2.50	280	910	2 275.00
2	120	7	10	4.67	1 200	1 937.14	9 046.44
3	10	3	23	9.00	230	23.33	209.97
Total:	200	15	-	-	1 710	-	11 530.97

$$\hat{Y}_{st} = \sum_i N_i \bar{y}_i = 1\,710 \text{ t}$$

$$\bar{y}_{st} = \frac{1\,710}{200} = 8.55 \text{ t}$$

$$v(\hat{Y}_{st}) = 11\,530.97 \quad \text{and} \quad s_{\hat{Y}_{st}} = \sqrt{v(\hat{Y}_{st})} = 107.38$$

There, $$cv(\hat{Y}_{st}) = \frac{107.38}{710} = 0.06 \; ; \; \text{i.e., } 6\%.$$

$$v(\bar{y}_{st}) = \frac{11\,530.97}{40\,000} = .2\,883 \quad \text{and} \quad s_{\bar{y}_{st}} = .54$$

Note: If there was no stratification, and we had chosen a simple random selection of 15 units, and their catches were as in Example 5, we would have:

$$\bar{y} = \frac{\Sigma y}{n} = \frac{159}{15} = 10.06 \text{ t}; \quad \text{and} \quad s_y^2 = \frac{1}{n-1}\left[\Sigma y^2 - \frac{(\Sigma y)^2}{n}\right] = 38.82$$

and,

$$\hat{Y} = 10.06 \times 200 = 2\,012 \text{ t}$$

Therefore,

$$v(\bar{y}) = \left(\frac{1}{n} - \frac{1}{N}\right)s_y^2 = .0616 \times 38.82 = 2.39$$

$$s_{\bar{y}} = 1.55$$

and, $$v(\hat{Y}) = N^2 \, v(\bar{y}) = 40\,000 \times 2.39 = 95\,600$$

$$s_{\hat{Y}} = 309.19$$

Therefore,

$$cv(\hat{Y}) = \frac{309.19}{2\,012} = .15 \text{ (i.e. 15\%)}$$

Clearly, by stratification, we have obtained an estimate with lower $cv(\hat{Y})$ than in the case of a simple random selection.

5.1 Sample Size in Different Strata

In Example 5, we selected a sample of 15 units, and the allocation of number of units in the different strata was done arbitrarily.

Now, when the sampling fraction is negligible, we know from equation (5.5) that variance of the population total is given by:

$$v(\hat{Y}_{st}) = \Sigma \, N_i^2 \, \frac{s_i^2}{n_i}$$

This equation suggests two methods of allocation of n among the different strata:

(a) Proportional allocation:
In this method, n_i is proportional to N_i. If within-stratum variances are equal, the method gives the smallest sampling variance, i.e., the most efficient estimates. Generally, the proportional allocation is used when information on strata variances are not available.

(b) Optimum allocation:
When the within-strata variances differ greatly from stratum to stratum, the proportional allocation no longer provides best estimates. In such cases, it is better that the sampling fraction is taken proportional to the stratum standard deviation.

For further details on these, one is referred to books of sampling designs (e.g., Yates, Bazigos, 1974).

Example 5.1

The following catches (kg) were obtained in 18 hauls of a trawl survey:

200, 440, 600, 640, 700, 800, 900, 1 020, 1 600, 1 920
20, 10, 340, 400, 720
40, 100, 160

(a) If the trawl net covered 40 ha per haul and if 50% of all fish in its path was caught and the total survey area was 6×10^6 ha, estimate the total abundance of fish.

(b) If the first 10 hauls were taken in depths 0-20 m, the next 5 in depths 20-40 m, and the last three in depths over 40 m and the areas of the depth zones are 1×10^6, 2×10^6 and 3×10^6 ha respectively, what will be the estimate of abundance?

(c) Find the variances of the above two estimates.

Solution

(a) Unstratified Sample

Let $\bar{y}$ be the mean catch, and if a is the area swept by each haul, the catch per hectare is $\bar{y}/a$. Since the net catches only 50%, i.e., the catchability coefficient q is $1/2$, the density of stock per hectare is: $\frac{\bar{y}}{aq}$.

Therefore, estimated abundances for the survey area A are:

$$B = \frac{A}{aq} \cdot \bar{y}$$

and, $$v(B) = \left(\frac{A}{aq}\right)^2 \text{var. } \bar{y} = \left(\frac{A}{aq}\right)^2 \frac{\text{var } (y)}{n}$$

where n is the number of sample hauls.

Now we have,

$$\bar{y} = 589.44 \text{ kg}; \quad v(y) = 282\,805.56$$

$$A = 6 \times 10^6 \text{ ha}; \quad a = 40 \text{ ha}; \quad \text{and } q = \frac{1}{2}$$

Therefore, $\hat{B} = \frac{6 \times 10^6}{4 \times \frac{1}{2}} \times 589.44 \text{ kg} = 176\,830 \text{ t}$

and, $$v(\hat{B}) = \left(\frac{6 \times 10^6 \times 2}{40}\right)^2 \times \frac{282\,805.56}{18}$$

$$= 10^{12} \times 1\,414.03 \text{ kg}^2$$

$$s(\hat{B}) = \sqrt{v(\hat{B})} = 10^6 \times 37.60 \text{ kg} = 37\,600 \text{ t}$$

$$cv(\hat{B}) = \frac{s(\hat{B})}{\hat{B}} \times 100 = 21.26\%$$

(b) Stratified Sample

In this case, $$\hat{B} = \Sigma \hat{B}_i = \Sigma \frac{A_i}{a_i q_i} \bar{y}_i ,$$

and, $$v(\hat{B}) = \Sigma \left(\frac{A_i}{a_i q_i}\right)^2 \text{var } (\bar{y}_i)$$

The nummerical calculations may be done conveniently in a tabular fashion:

Stratum	n_i	$\bar{y}_i$ (kg)	s_i^2	A_i	$\frac{A_i}{qa}$	$B_i = \frac{A_i \bar{y}_i}{qa}$ (t)	$(\frac{A_i}{qa})^2 \frac{s_i^2}{n_i}$ (kg^2)
1	10	882	272 306.67	1×10^6	50×10^3	44 100	$10^{12} \times 66.08$
2	5	298	87 620.00	2×10^6	100×10^3	29 800	$10^{12} \times 175.24$
3	3	100	3 600.00	3×10^6	150×10^3	15 000	$10^{12} \times 27.00$
					$\hat{B}$ =	88 900	$10^{12} \times 270.32$

and, $v_{st}(\hat{B}) = 10^{12} \times 270.32 \text{ kg}^2$

and $s(\hat{B}_{str}) = \sqrt{10^{12} \times 270.32} = 16\ 440$ t

Therefore, $cv(\hat{B}_{str}) = \frac{16\ 440}{88\ 900} \times 100 = 18.47\%$

Ratio Estimation

This is another method in which use is made of auxiliary information to increase the precision. Let us suppose we have selected at random n units out of N units in the population and for each of these selected units we have measured (x,y), where y is the survey variate and x is another correlated variate. The population total of x-variate is known to be:

$$X = \sum_1^N x_i ,$$

but y may not be known for each unit of the population except for those in the sample. In this case, an estimate of the population total Y of the survey variate is given by: $\hat{Y}_{rat} = \hat{R} X$, where the estimate R is obtained from the sample as:

$$\hat{R} = \frac{\sum_1^n y_i}{\sum_1^n x_i}$$

The variance of the ratio estimate $\hat{Y}_{rat}$ is given by:

$$v(\hat{Y}_{rat}) = \frac{N \cdot (N-n)}{n} [s_y^2 + \hat{R}^2 s_x^2 - 2\hat{R} s_x s_y . r] \qquad (6.1)$$

where, r is the estimated coefficient of correlation between x and y.

Example 6.1

There are 50 landing centres in a country where shrimp trawlers land. The shrimp trawlers are registered and the total from the Registration Record is known to be 280. Now, 5 landing centres are selected at random and the catch (y) and the number of trawlers (x) at each of the 5 landing centres are obtained. Make a ratio estimate Y_{rat} of the total landings by the shrimp trawlers in the country.

We have,

Landing centres: Total - N = 50
Sample - n = 5

Trawlers: Total - X = 280

We have,

Sample landing centres	No. of trawlers (x)	Catch (y) (t)	x^2	y^2	xy
1	2	22	4	484	44
2	10	95	100	9 025	950
3	7	62	49	3 844	434
4	3	33	9	1 089	99
5	8	83	64	6 889	664
Total:	30	295	226	21 331	2 191

We have,

$$s_x^2 = \frac{1}{n-1}\left[\Sigma x^2 - \frac{(\Sigma x)^2}{n}\right] = 11.5$$

$$s_y^2 = \frac{1}{n-1}\left[\Sigma y^2 - \frac{(\Sigma y)^2}{n}\right] = 981.5$$

$$s_{xy} = \frac{1}{m-1}\left[\Sigma xy - \frac{\Sigma x.\Sigma y}{n}\right] = 105.25$$

$$r = \frac{s_{xy}}{\sqrt{s_x^2.s_y^2}} = .99$$

and,

$$\hat{R} = \frac{\sum_1^n y_i}{\sum_1^n x_i} = \frac{295}{30} = 9.83$$

Therefore,

$$\hat{Y}_{rat} = \hat{R}\,X = 9.83 \times 280 = 2\,752.40 \text{ t}$$

and from equation (6.1),

$$v(\hat{Y}_{rat}) = \frac{50 \times 45}{5}\left[981.50 + (9.83)^2 \times 11.5 - 2 \times 9.83 \times .99 \times \sqrt{11.5 \times 981.5}\right]$$

$$= 11\,578.50$$

and,

$$s_{\hat{Y}_{rat}} = \sqrt{11\,578.50} = 107.60$$

Therefore,

$$cv(\hat{Y}_{rat}) = \frac{107.60}{2\,752.40} = .04 \text{ (i.e., 4\%)}$$

7. UNEQUAL PROBABILITY SAMPLING

We have seen that by stratification and ratio estimation we can increase the precision of estimate. Another technique used for this purpose is pps sampling, i.e., where the sampling units are selected with probabilities proportional to their sizes. This is widely used in cases where sampling of clusters is preferred to direct sampling of individual units, the reasons being that it is economical to sample a fixed number of individual units when they are in clusters and that sometimes reliable frame of individual units are not available.

7.1 Method of Selection

Suppose there are 10 landing sites with number of boats at each landing sites shown in Col. 2. We want to select 3 sites with pps.

Landing site (1)	No.of boats (2)	Cumulative total (3)	Allotted numbers (4)	Selected random no. or fishing site (5)
1	12	12	001-012	
2	5	17	013-017	Random no. 011
3	20	37	018-037	Fishing site 01
4	2	39	038-039	Random no. 027
5	30	69	040-069	Fishing site 03
6	15	84	070-084	Random no. 064
7	8	92	085-092	Fishing site 05
8	6	98	093-098	
9	8	106	099-106	
10	14	120	107-120	
	120			

Column 3 is the cumulative total. Now each landing site is given a number proportional to its size. Thus the landing site 1 gets 12 numbers, 001-012, allotted to it, the landing centre 5 gets 30 numbers from 040-069 allotted to it, and so on. Then we use the random number table and select 3 numbers between 1 and 120. These selected numbers are: 011, 027 and 064. The corresponding fishing sites selected are: 01, 03 and 05.

It may be noted that in this method of selection a unit with a larger size has a higher chance of selection than a unit of a smaller size.

7.2 Method of Estimation

Let there be N primary sampling units (fishing sites) and let x_i be the number of secondary units (boats) in the i^{th} landing site. If n primary units are selected with pps, then the probability of selecting the i^{th} unit in the sample is: $p_i = \frac{x_i}{\Sigma x_i}$.

The estimate of the Population Total Y is given by:

$$\hat{Y} = \frac{1}{n} \sum_i \frac{y_i}{p_i} \qquad (7.2.1)$$

where y_i is the measurement of the i^{th} unit in the sample; and the estimated variance of Y is given by:

$$v(\hat{Y}) = \frac{1}{n(n-1)} \sum_{i=1}^{n} \left(\frac{y_i}{p_i} - \hat{Y}\right)^2 \qquad (7.2.2)$$

$$= \frac{1}{n(n-1)} \left[\Sigma t_i^2 - \frac{(\Sigma t_i)^2}{n}\right]$$

where, $t_i = \frac{y_i}{p_i}$

Example 7.2

There are 20 fishing sites in a district. The number of boats at each centre is known, i.e., x_i = number of boats at the i^{th} centre is known, and therefore $X = \Sigma x_i$ is known to be 496. Four fishing sites are selected out of 20 fishing sites with pps. In the table below, Col. 1 gives the 4 fishing sites selected in the sample, Col. 2 gives the number of boats (x) in these sites, and Col. 3 gives the landings at these sites during a month. Estimate the total monthly landings $\hat{Y}$ and $v(\hat{Y})$.

Sample sites	No.of boats (x_i)	Landings (in t.) (y_i)	$p_i = \frac{x_i}{X}$	$t_i = \frac{y_i}{p_i}$	t^2
(1)	(2)	(3)	(4)	(5)	(6)
1	22	81	0.0443	1 828	3 341 584
2	30	118	0.0605	1 950	3 802 500
3	30	118	0.0605	1 950	3 802 500
4	42	170	0.0847	2 007	4 028 049
Total:				7 735	14 974 633

Using (7.2.1), we get: $\hat{Y} = \frac{1}{4} \sum_{1}^{4} t_i = \frac{7\ 735}{4} = 1\ 934$ t

Using (7.2.2), we get: $v(\hat{Y}) = \frac{1}{12} [14\ 974\ 633 - \frac{(7\ 735)^2}{4}] = 1\ 423$

$$cv(\hat{Y}) = \frac{\sqrt{1\ 423}}{1\ 934} = .019 \text{ (i.e., 1.9\%)}$$

8. TWO-STAGE SAMPLING

In two-stage sampling, a sample of first-stage units are chosen first, and in each of the selected first-stage units, a further sample of survey units is chosen. A simple random selection may be made for the first-stage units or they can be selected with probability proportional to their sizes.

8.1 Selection of First-Stage Units at Random (SRS)

Let us have:

N = Number of first-stage units

n = Number of first-stage sample units

M_i = Number of survey units in the i^{th} first-stage unit

m_i = Number of survey units selected in the i^{th} first-stage unit

$f_i = \frac{n}{N}$ = First-stage sampling fraction

$f_{2i} = \frac{m_i}{M_i}$ = Second-stage sampling fraction in the i^{th} primary unit

The unbiased estimate of the population total of the survey characteristic (y) is given by:

$$\hat{Y} = \frac{N}{n} \Sigma M_i \bar{y}_i \qquad (8.1.1)$$

where $\bar{y}_i = \frac{1}{m_i} \sum_{j=1}^{m_i} y_{ij}$ and $\hat{Y}_i = M_i \bar{y}_i$

and its estimated variance is given by:

$$v(\hat{Y}) = \frac{N(N-n)}{n} \cdot \frac{1}{n-1} \sum_{1}^{n} [\hat{Y}_i - \frac{\Sigma \hat{Y}_i}{n}]^2 + \frac{N}{n} \Sigma \frac{M_i (M_i - m_i)}{m_i} s_i^2$$

where, $$s_i^2 = \frac{1}{m_i - 1}\left[\sum_{j=1}^{m_i} y_{ij}^2 - \frac{(\sum_{j=1}^{m_i} y_{ij})^2}{m_i}\right]$$

Example 8.1

Let there be 8 fishing sites (N=8). We first select n=3 fishing sites at random and for each fishing site we select 3 traps and measure their catch. The number of traps existing at each selected fishing site and the catches of each selected trap are shown below. Calculate the estimated total catch of trap fisheries and its variance.

Sample sites	1	2	3
No. of traps at each site (M_i)	6	9	7
No. of traps selected (m_i)	3	3	3
Catches of selected traps	13	5	12
	9	7	8
	6	10	13
Sample total	28	22	33
s_i^2	12.3	6.3	7.0

Estimated total landings,

$$\hat{Y} = \frac{N}{n}\sum M_i \bar{y}_i$$

$$= \frac{8}{3}\left(6 \times \frac{28}{3} + 9 \times \frac{22}{3} + \frac{33}{3} \times 7\right)$$

$$= 531$$

$$v(\hat{Y}) = \frac{8 \times 5}{3} \cdot \frac{1}{2} \times 221 + \frac{8}{3}\left[\left(\frac{6 \times 3}{3} \times 12.3 + \left(\frac{9 \times 6}{3} \times 6.3\right) + \left(\frac{7 \times 4}{3}\right.\right.\right. \left.\left.\left. 7.0\right)\right]$$

$$= 1\,473 + 673.3 = 2\,146.6$$

$$cv(\hat{Y}) = \frac{\sqrt{2\,146.6}}{531} \cdot 100 = 8.73\%$$

It may be noted that the contribution 1 473.3 to $v(\hat{Y})$ is due to difference in the obtained catches between the fishing sites and this is much greater than 673.3 which is due to difference among second-stage units within the first-stage units.

8.2 Selection of First-Stage Units with PPS

The estimated catch in the i^{th} fishing site is given by:

$$\hat{Y}_i = \frac{M_i}{m_i}\sum_{j}^{m_i} y_{ij}$$

The unbiased estimate of the population total is given by:

$$\hat{Y} = \frac{1}{n}\sum_{i=1}^{n}\frac{\hat{Y}_i}{p_i} = \frac{1}{n}\sum_{i=1}^{n} t_i$$

The variance of Y is given by:

$$v(\hat{Y}) = \frac{1}{n} \cdot \frac{1}{n-1} \left[\Sigma\, t_i^2 - \frac{(\Sigma t_i)^2}{n}\right]$$

Example 8.2

Three fishing sites were chosen with pps and within each sample fishing site a simple random sample of boats were selected. In the table below we give catches (in kg) of selected sample. Calculate $\bar{Y}$ and $cv(\bar{Y})$.

Sample fishing site	p_i	$\frac{M_i}{m_i} = \frac{1}{P_{2i}}$	$\sum_{j=1}^{m_i} y_{ij}$	$\bar{Y}_i$	$t_i = \frac{\bar{Y}_i}{p_i}$	t_i^2
1	$\frac{30}{1\,000}$	6	120	720	24 000	576 000
2	$\frac{50}{1\,000}$	5	200	1 000	20 000	400 000
3	$\frac{10}{1\,000}$	2	110	200	22 000	484 000
Total:					66 000	1 460 000

We therefore have,

$$\bar{Y} = \frac{1}{n} \Sigma \frac{\hat{Y}_i}{p_i} = \frac{1}{n} \Sigma t_i = \frac{66\,000}{3} = 22\,000 \text{ kg}$$

and,

$$v(\bar{Y}) = \frac{1}{3} \cdot \frac{1}{2} \left[1\,460\,000 - \frac{(66\,000)^2}{3}\right] = 1\,333\,333$$

and,

$$cv(\bar{Y}) = \frac{\sqrt{1\,333\,333}}{22\,000}\, 100 = 5.25\%$$

APPENDIX TABLE 1:

Table of Random Numbers

1	2	3	4	5	6	7	8	9	10	11	12
13	70	43	69	38	81	87	42	12	20	41	15
26	99	82	78	99	05	22	99	52	32	80	91
72	53	95	81	07	98	14	74	52	58	73	10
22	08	08	68	37	16	36	62	20	02	35	98
21	61	90	53	85	72	86	94	87	18	50	11
47	38	55	66	50	96	96	78	34	45	52	78
96	68	13	07	31	29	70	09	16	66	81	09
45	92	93	44	87	72	26	75	82	31	72	69
78	85	71	45	32	16	57	91	52	05	93	20
51	99	50	88	62	54	90	51	01	39	18	70
67	62	30	02	88	17	37	25	42	86	00	32
03	08	89	77	12	41	15	25	52	30	93	11
45	10	04	66	94	70	33	74	97	23	40	97
62	48	46	97	04	36	31	27	29	84	85	35
59	59	33	63	53	43	60	30	15	81	67	59
72	63	67	17	24	55	68	32	24	80	13	92
46	28	15	70	28	98	53	36	03	89	83	74
21	03	09	16	31	48	05	10	98	62	14	15
84	82	53	39	92	14	07	84	04	01	66	17
75	68	40	90	39	95	46	10	94	68	39	10
42	77	29	80	73	38	92	11	81	72	50	88
63	55	09	84	66	56	92	13	97	14	87	27
54	29	70	14	85	95	79	72	77	48	57	92
42	97	50	61	19	55	38	55	85	57	85	08
52	30	47	73	26	54	18	05	75	92	95	08
88	44	33	02	47	97	47	04	12	38	93	25
49	91	93	73	14	15	01	47	02	70	30	96
45	42	46	06	93	60	41	09	31	29	52	49
50	69	74	10	51	89	66	51	57	21	54	95
18	56	73	16	02	87	41	05	13	87	13	61

Tables of Random Numbers (from Bazigos, 1974)

APPENDIX TABLE 1 (Cont'd)

13	14	15	16	17	18	19	20	21	22	23	24
76	96	85	27	81	21	75	39	43	77	80	81
38	51	09	17	41	85	13	20	66	59	22	20
40	91	90	51	74	23	54	88	84	12	16	77
44	53	23	87	91	53	86	97	42	80	83	37
31	25	22	30	16	17	32	34	00	07	25	52
36	35	20	92	81	12	15	28	42	98	67	52
36	12	17	03	83	93	48	64	50	32	57	94
25	51	40	74	85	16	86	09	22	62	06	38
72	38	33	97	36	58	90	91	23	91	19	04
17	20	75	03	85	53	06	41	29	78	51	15
75	57	37	77	67	60	70	44	56	91	03	49
12	47	35	37	15	17	96	24	95	08	39	55
73	67	55	64	16	38	58	74	29	71	49	62
16	02	29	14	16	78	44	49	34	05	46	96
48	98	13	29	19	71	98	71	19	51	86	82
73	65	42	09	39	92	56	68	36	54	55	46
22	96	06	41	55	75	08	62	55	19	15	15
57	26	11	28	98	16	85	39	67	49	02	30
47	76	60	92	22	79	70	66	78	13	97	42
31	80	30	86	08	54	39	88	38	46	74	21
91	55	48	36	26	40	17	70	39	94	05	76
83	70	10	91	20	64	12	33	15	59	43	28
28	35	53	14	30	57	07	34	09	56	26	81
86	91	62	94	83	96	96	17	02	10	89	71
24	86	86	52	67	59	63	22	28	76	43	45
43	73	70	73	19	41	04	60	25	42	09	50
52	69	34	01	65	33	19	62	22	41	29	65
01	15	92	69	53	78	68	58	74	08	05	11
94	46	83	72	49	19	98	09	56	83	25	40
44	42	06	32	95	17	32	67	80	84	09	69
81	58	85	33	16	11	87	12	17	39	12	11
60	25	84	42	22	94	38	96	52	03	38	97
53	12	75	59	76	42	73	48	95	57	51	31
02	68	01	17	09	00	38	12	31	52	22	24
09	68	53	92	82	11	96	03	47	31	35	59

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ISBN 92-5-102256-9